EFFECTS OF INTENSIVE FOREST MANAGEMENT ON BREEDING BIRDS OF VANCOUVER ISLAND

Problem Analysis

INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH

BC

A cooperative project between the Ministry of Environment and Parks and the Ministry of Forests and Lands

EFFECTS OF INTENSIVE FOREST MANAGEMENT ON BREEDING BIRDS OF VANCOUVER ISLAND

Problem Analysis

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PREFACE

This publication is one of three companion publications resulting from a problem analysis on the effects of intensive forest management on non-ungulate wildlife of Vancouver Island. Non-ungulate species include all amphibian, reptile, bird, and mammal (excluding deer and elk) species that occur on Vancouver Island.

Several factors, in conjunction with the demands imposed by an increase in public awareness, were responsible for the initial problem analysis proposal. First, while management efforts on Vancouver Island will continue to focus on deer and elk, interest is increasing in other game and non-game species. Second, experience elsewhere indicates that, with the increased concern for the welfare of these species, the demand for their greater protection and management will also increase. Third, it is likely that intensive forest management will affect these species at least as significantly as it has affected deer and elk. Finally, our knowledge of the habitats of these species is very limited.

What is known, though, is that timber harvesting is the major factor affecting species habitats on Vancouver Island. Begun over a century ago, logging has since altered a major portion of the forested land on Vancouver Island. Because the Island has one of the most productive timber producing climates in the province, timber harvesting and its associated intensive forestry practices will continue to play a major role in altering species habitats.

Wildlife management is the responsibility of the Wildlife Branch (British Columbia Ministry of Environment and Parks); the public land base on which the wildlife live is primarily under the control of the Ministry of Forests and Lands.

The goals of wildlife management in British Columbia are:

1. to maintain the diversity of species representative of the major biophysical zones of the province; and
2. to ensure that within the constraints of land capability and biological limits of each species, wildlife is available in sufficient abundance to meet the recreational and economic needs of society.

To meet these goals, objectives, policies, and management prescriptions have been developed and are presented in a series of draft management documents prepared by the Wildlife Branch.

The Ministry of Forests Act dictates that the Ministry is responsible for planning "...the use of the forest and range resources of the Crown so that the production of timber and forage; the harvesting of timber; the grazing of livestock; and the realization of fisheries, wildlife, water, outdoor recreation and other natural resources values are coordinated and integrated, in consultation and cooperation with other ministries and agencies of the Crown and with the private sector" (Ministry of Forests Act 1980, Section 4c).

Implementation of these two ministerial mandates are the guiding forces influencing the interactive management of forests and wildlife.

The OBJECTIVE of the problem analysis is:

> TO IDENTIFY RESEARCH QUESTIONS AND PRIORITIES REGARDING THE HABITAT REQUIREMENTS AND THE EFFECTS OF INTENSIVE FOREST MANAGEMENT ON THE NON-UNGULATE WILDLIFE OF VANCOUVER ISLAND.

To facilitate the analysis of the large number of non-ungulate species to be considered in this project, species were grouped under three general taxonomic headings: 1) amphibians and reptiles; 2) mammals; and 3) birds. A total of 195 non-ungulate species were considered. Within each group, species were further organized by lifeform -- an assemblage of species with similar reproductive and feeding strategies (Niemi and Pfannuller 1979). Organizing species into lifeforms was designed to assist identification of the habitat requirements and effects of intensive forest management common to all or a majority of the species in the lifeform. Information on each of the three species groups was compiled, organized and analysed separately. Although this resulted in some differences in format, the topics addressed were the same. These topics include: the problem; wildlife management objectives and policies; species distribution, status, protection, numbers, and habitat requirements; and effects of intensive forest management. Research recommendations, designed to address the information needs identified, conclude each analysis.

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Since this is the third and final companion publication for this project, I wish to extend special thanks to the Research Branch typing support staff for their continued patience throughout the production of this manuscript and the duration of this project.

Finally, to Rick Ellis, I would like to express my appreciation for his continued support and for the opportunity and rewarding challenge this project has provided.

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1 INTRODUCTION

The physiographic and floristic diversity found in British Columbia creates a habitat diversity which has enabled over 400 bird species to occur in the province. Of the 357 indigenous species occurring in B.C., 282 (79%) are breeding bird species (Campbell 1984). This represents approximately 70% of the total number of species breeding in Canada (Bunnell and Williams 1980) and illustrates the rich breeding bird community found in British Columbia (hereafter B.C.).

Vancouver Island provides breeding habitat for 48% of the Province's breeding bird species. This includes 131 indigenous and 8 introduced species (Appendix 1). While some of these species occur only in the breeding season, many are resident species.

This analysis will discuss only species breeding on Vancouver Island. This group of species was selected for several reasons: (1) a large proportion of species occurring on Vancouver Island are breeding species; (2) many are also resident species; (3) their occurrence is directly affected by their reproductive success; and (4) the effects of intensive forest management and concerns for these species will probably be similar for species occurring in other seasons. The assumption is that species occurrence is predetermined by the availability of their breeding habitat, and conversely that any alteration to or elimination of their habitat will ultimately affect their occurrence. This is the major reason for this focus on breeding bird species. Furthermore, it was felt that with the provision of habitat for breeding bird species, habitat for wintering, migratory, and resident species would, for the majority, also be provided.

2 PROBLEM

Although there has been a long history of bird appreciation by birdwatchers and sportsmen, bird management in B.C. has largely been passive. Management programs (with measurable objectives) have traditionally focused only on game bird species such as ducks, geese and grouse. Increasing pressure on the land base, however, has initiated concern for all bird species. Accordingly, Preliminary Management Plans have been developed for

B.C.'s bird species (B.C. Ministry of Environment 1979a, 1979b and 1979c, 1980, 1981a and 1981b). A summary of the problems identified by the Wildlife Branch (formerly the Fish and Wildlife Branch, pre-October 1984) while developing these species management plans is presented in Table 1. Two problems that have particular bearing on this analysis are (1) the inadequacy or lack of species distribution and inventory information and (2) the lack of species habitat requirement information. Information is available in a generalized form (Guiguet 1954, 1955a, 1955b, 1957, 1958, 1960 and 1964, Godfrey 1966, Guiguet 1972, 1978), but, actual species distribution data (i.e. via sight records[1]) are lacking for much of Vancouver Island and many of its bird species. Inventory programs have been developed for only a few species (Section 6). (The difficulty in developing inventory programs for raptors and non-game birds is a recognized problem.) As well, few studies in B.C. focused on the habitat requirements of coastal forest birds, and most of the information that is available on Vancouver Island species originates from the United States. Extrapolation of species and/or habitat information is not always valid (Campbell pers. comm.). Information on species distributions and habitat requirements specific to the locale is fundamental to sound species management.

It has long been recognized that birds respond to environmental features particularly vegetative physiognomy (MacArthur and MacArthur 1961, MacArthur et al. 1962, see also Section 9.1). On Vancouver Island, intensive forest management practices are the principal cause of alteration to the vegetation structure. In the Preliminary Management Plans, the Wildlife Branch recognizes destruction of a species' habitat (or the habitat of its prey) as a major problem and one common to all of Vancouver Island's bird species.

Wildlife biologists will be unable to make informed bird management decisions and provide guidelines for forest managers unless species distributions, habitat requirements, and information on bird-forestry interrelationships are better known.

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[1] Sight records include published records, museum specimens, and species observations records.

TABLE 1. Management problems

	Habitat requirement info unknown	Destruction of habitat (or prey)	Distribution and/or inventory lacking or inadequate	Inventory info difficult to obtain	Harvest info lacking	Illegal harvesting	Cause damage to agric. crops	Chemicals have detrimental effect
Canada Goose		X	X				X	
Ducks		X	X				X	
Upland Game Birds		X			X			X
Raptors		X[a]	X	X		X		X
Non-game Birds	X	X	X	X			X	
Threatened and Endangered Species[b]	X	X	X	X				

[a] Habitat of their prey species.
[b] Peregrine Falcon (Falco peregrinus anatum); F. p. anatum is the interior race; F. p. pealei is the coastal race.

Source: Preliminary Wildlife Management Plans for British Columbia (B.C. Ministry of Environment 1979a-c, 1980, 1981a, 1981b).

3 MANAGEMENT POLICIES AND OBJECTIVES

The two primary management policies as outlined in the Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-c, 1980, 1981a, 1981b) are hunting and non-hunting recreation. Hunting is the first priority management use for upland gamebirds and ducks, and the second priority use for Canada geese. In contrast, non-hunting recreation is the first priority management use for raptors, non-game birds, and Canada geese, and the second priority use for upland gamebirds and ducks.

Although active management will undoubtedly continue to focus on game species, management objectives have been also developed to include population maintenance, habitat enhancement and support of co-operative species surveys for the non-game bird species (Table 2).

4 PROTECTION

Birds in B.C. are protected by the provincial Wildlife Act (1982) and the federal Migratory Bird Convention Act (Canadian Wildlife Service 1980). For migratory species (see Canadian Wildlife Service [1980] for recent list), jurisdiction is shared by both levels of government. All except three of Vancouver Island's breeding birds are covered in the legislation. The European Starling, Rock Dove and House Sparrow are unprotected introduced species.

5 STATUS

No Vancouver Island breeding bird species (or subspecies) have an official status designation under the current legislation. The status of most bird species in B.C. is unknown due to a lack of inventory information.

In an attempt to identify and monitor bird species in decline, several species lists have been developed. Responding to the "Preliminary Plan for the Designation of Threatened and Endangered Species in British Columbia" (B.C. Ministry of Environment 1979a), Weber (1980) developed a list of rare and endangered breeding birds, including peripheral species and subspecies. He states that, "Designation of endangered species should be made strictly on the basis of population status and ecology; other factors ... should come into play only in deciding which forms should receive management priorities".

TABLE 2. Management objectives

	Canada Goose	Uplands Game Birds	Raptors	Duck	Non-game Birds
Maintain viable population		X[a]	X[b]		
Maintain present diversity and range		X		X	X
Population enhancement	X		X[c]		
Habitat enhancement		X			X
Identification and preservation of species rich or specialized areas					X
Support co-operative population surveys					X
Provide population for sustained-yield harvest	X	X	X[d]	X	
Provide hunter days	X	X		X	
Reduce conflict with intensive agriculture	X				
Provide public viewing areas	X			X	

[a] Of introduced species.
[b] Within historical range.
[c] In areas of serious decline.
[d] For falconry purposes only.

Source: Preliminary Wildlife Management Plans for British Columbia (B.C. Ministry of Environment 1979b, 1979c, 1980, 1981a, 1981b).

(Weber 1980:162). The National Audubon Society's Blue List was initiated in 1971 and its objective was to "list [the species] which have recently given or are currently giving indications of non-cyclical population declines or range contractions, whether locally or widespread." (Anon. 1971:948 from Tate 1981). This list is based on species information contributed by regional coordinators throughout North America. Finally, the Canadian Wildlife Service (CWS) recently developed a priority (migratory) bird species list (Boyd 1982) for use in its Regional Habitat Preservation Plan. Although it was not intended to identify threatened and endangered species, the criteria used to develop the list were based on population status, ecology, and impact vulnerability, and thus drew attention to species of special concern.

Although these three lists are not official, they are valuable for the information they provide (Table 3). This collection of species statuses was used to assist in formulating and evaluating topics for research (Section 11).

6 PROGRAMS

Until very recently, few programs on forest birds had been undertaken by the provincial and federal government agencies responsible for their maintenance. The Wildlife Branch, although conducting studies elsewhere in the province, currently does not have any research programs proposed for Vancouver Island (Munro pers. comm.). The British Columbia Provincial Museum (BCPM) has several forest bird studies under way, one on Vancouver Island (Campbell pers. comm.). This study is on the co-existence of forest raptors (owls and hawks). The information from another study on the winter habitat requirements of Bald Eagles, although being conducted on the coastal mainland, could certainly apply to the populations on Vancouver Island. The CWS, historically concerned primarily with migratory waterfowl, has recently expanded its scope to include forest birds. The major focus thus far has been the effects of logging on bird populations in three biogeoclimatic zones (coastal western hemlock, interior Douglas-fir, ponderosa pine-bunchgrass) on the B.C. mainland (Wetmore pers. comm.). Other topics under study include bird predation on forest insect pests and the modelling of the relationships

TABLE 3. Status of some Vancouver Island breeding birds

	B.C. Fish & Wildlife[1]	COSEWIC 1983[2]	CWS 1982[3]	Weber 1980[4]	BLUE LIST 1981[5]
LIFEFORM 1					
Common Loon					X
Red-throated Loon					O
Red-necked Grebe			26[a]		X
Great Blue Heron			19	SC	X
Harlequin Duck			22		
Osprey				SC	X
Sandhill Crane			6	T	
Mew Gull			27		
Common Yellowthroat					O
LIFEFORM 2					
Turkey Vulture					O
Peregrine Falcon					E[b]
F. p. pealei		R		T	
White-tailed Ptarmigan					
L. l. saxatilis				SU	
Cliff Swallow					X
LIFEFORM 3					
Short-eared Owl					X
Common Nighthawk					X
Horned Lark				E,P	
Willow Flycatcher					X
Yellow Warbler					X[c]
Fox Sparrow					O
LIFEFORM 5					
Warbling Vireo					O
LIFEFORM 6					
Golden-crowned Kinglet					X
Ruby-crowned Kinglet					O
LIFEFORM 7					
Cooper's Hawk					X
Merlin					X
LIFEFORM 8					
Pileated Woodpecker			7		
Hairy Woodpecker					X[c]
LIFEFORM 9					
Wood Duck			33		
Hooded Merganser			24		
American Kestrel					X
Common Barn-Owl				SC,P	X
Western Screech-Owl					X
Vaux's Swift			31		
Purple Martin				SC[d]	X[c]
Bewick's Wren					X
Winter Wren					O

TABLE 3. Status of some Vancouver Island breeding birds - cont'd.

	B.C. Fish & Wildlife[1]	COSEWIC 1983[2]	CWS 1982[3]	Weber 1980[4]	BLUE LIST (USA)[5]
LIFEFORM 11					
Fork-tailed Storm Petrel			9		0
Leach's Storm Petrel			18		
Double-crested Cormorant					X
Black Oystercatcher			32		
Common Murre			4	SC	
Cassin's Auklet			3		
Rhinoceros Auklet			23		
Tufted Puffin			5		

NOTE: Species in lifeforms 4 and 10 were not included on any of these reference status lists.

T - threatened
E - endangered
R - rare
SC - special concern
SU - status undetermined
P - peripheral (range extends 80 km or less into B.C.)
X - species currently on 1981 list
O - species has been previously listed but not on 1981 list

a - number denotes species ranking out of total of 33 species selected for designation
b - listed as endangered by U.S. Bureau of Sport Fisheries and Wildlife (1973) from Weber (1980)
c - widespread species but local declines or noted decline in PNW states
d - local declining and/or endangered in a major part of its B.C. range

Sources:

1 Preliminary Plan for the Designation of Threatened and Endangered Species in British Columbia (B.C. Ministry of Environment 1979c).

2 Committee on the Status of Endangered Wildlife in Canada, December 1983.

3 Preliminary Priority Migratory Bird Species List for the Pacific and Yukon Region (Boyd 1982).

4 Weber (1980) in Proc. of "Threatened and Endangered Species and Habitats in British Columbia and the Yukon" (B.C. Ministry of Environment 1980).

5 National Audubon Society's Blue List (Tate 1981).

between forest bird densities and forest stand age. One study, a preliminary songbird survey of the Carnation Creek area on the west coast of Vancouver Island, has been completed (Fry 1982).

7 DISTRIBUTION

In comparison to species distribution data available on amphibians and reptiles and mammals of Vancouver Island (Sadoway 1986a and b), the amount of data available on bird species distribution is substantial. Housed within the BCPM complex (Vertebrate Zoology Division) is the bird record file, which is organized into three categories: (1) Bird Index (all recorded sightings[1]); (2) Nest Records (only); and (3) Seabird Colonies (history and inventory information of each colony site). Termed the B.C. Wildlife Record Scheme (BCWRS) (in reference to all records: amphibians, reptiles, mammals, birds) and the B.C. Nest Record Scheme (BCNRS) (in reference to all bird nest records), these records are continually being updated as species observations are reported, specimens are collected and literature is reviewed.[1]

Data from the BCNRS file were compiled for this problem analysis and provide the information on Vancouver Island's breeding bird distributions (Tables 4 and 5). Only data on the breeding bird species selected to represent each lifeform (hereafter referred to as "representative breeding bird species"; see Section 9.2 and Appendix 2) were compiled. These data were matched to the biogeoclimatic zones (Packee 1975, Klinka et al. 1977) and regions (Ellis 1980) described for Vancouver Island. Based on these data, the documented geographic distribution for each species is presented (Table 4). Also included is a general description of the geographic distribution as provided by Godfrey (1966) (Table 5).

During the compilation of these data, several important points concerning Vancouver Island's breeding bird species and their distribution were noted.

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[1] The BCPM is currently compiling species distribution maps for all non-passerine species using this data (Cooper pers. comm.).

TABLE 4. Distribution of representative breeding bird species on Vancouver Island by region and biogeoclimatic subzone, as indicated by B.C. Nest Record Scheme (1982)

Species	Life Form	Regions[a]: ALBERNI INLET-QUALICUM TO SOUTH					ALBERNI-QUALICUM TO MUCHALAT INLET-CAMPBELL R					MUCHALAT INLET-CAMPBELL R TO QUATSINO SND-PT MCNEILL				QUATSINO SND-PT MCNEILL TO NORTH				
		Douglas-fir Dry	Douglas-fir Wet	Western Hem Dry	Western Hem Wet	Mtn Hem[b]	Douglas-fir Dry[b]	Douglas-fir Wet	Western Hem Dry	Western Hem Wet	Mtn Hem	Douglas-fir Dry[b]	Douglas-fir Wet	Western Hem Dry	Western Hem Wet	Mtn Hem	Douglas-fir Dry	Douglas-fir Wet	Western Hem Dry[b]	Western Hem Wet	Mtn Hem[b]
		Biogeoclimatic Subzones																		
Common Loon	1	X	X		X			X	X	X			X	X						X	
Bald Eagle	1	X		X	X			X		X					X					X	
Spotted Sandpiper	1	X	X	X				X	X	X				X	X					X	
Peregrine Falcon	2	X													X					X	
Blue Grouse	3	X	X	X				X	X				X								
Common Nighthawk	3	X		X				X	X				X	X							
Savannah Sparrow	3	X																			
Yellow Warbler	4	X	X					X	X					X							
Fox Sparrow	4	X								X					X					X	
Warbling Vireo	5	X	X					X													
Black-headed Grosbeak	5	X						X													
Western Flycatcher	6	X	X					X													
Steller's Jay	6	X	X	X	X			X													
Townsend's Warbler	6	X	X							X											
Cooper's Hawk	7	X																			
Northwestern Crow	7	X	X		X			X		X					X						
Pileated Woodpecker	8	X						X													
Downy Woodpecker	8	X	X					X													
Western Screech-Owl	9	X						X													
Tree Swallow	9	X	X	X				X	X	X			X								
Chestnut-backed Chickadee	9	X		X																	
Belted Kingfisher	10	X	X	X	X			X	X						X					X	
Fork-tailed Storm-Petrel[c]	11				X					X					X					X	
Pelagic Cormorant	11	X	X		X					X					X					X	
Black Oystercatcher	11	X								X										X	

[a] Regional divisions after Ellis (1980).
[b] Biogeoclimatic zone or subzone not found in this region.
[c] All breeding sites on coastal islands.

Source: British Columbia Provincial Museum, Vertebrate Zoology Division, B.C. Nest Record Scheme (1982), Victoria, British Columbia.

TABLE 5. Distribution of representative breeding bird species on Vancouver Island, as indicated by B.C. Nest Record Scheme (1982): a summary[a]

Species	LIFE FORM	BIOGEOCLIMATIC SUBZONES					GEOGRAPHIC EXTENT[b]	
		Douglas-fir Dry	Douglas-fir Wet	Western Hem Dry	Western Hem Wet	Mtn Hem (zone)	Vancouver Island	B.C. Mainland
Common Loon	1	X	X	X	X		all Van Is	all B.C.
Bald Eagle	1	X	X	X	X		all Van Is	all B.C.
Spotted Sandpiper	1	X	X	X	X		all Van Is	all B.C.
Peregrine Falcon	2	X			X		SE Gulf Islands; MN Van Is; Scott Is. group	Q.C.I.
Blue Grouse	3	X	X	X			all Van Is.	all B.C.
Common Nighthawk	3	X	X	X			all Van Is	all B.C.
Savannah Sparrow	3	X					all Van Is	all B.C.
Yellow Warbler	4	X	X				all Van Is	all B.C.
Fox Sparrow	4	X		X			all Van Is	all B.C.
Warbling Vireo	5	X	X				all Van Is	all B.C.
Black-headed Grosbeak	5	X					Duncan south	southern 2/3 of B.C.
Western Flycatcher	6	X	X				all Van Is	coast; southern 1/3 of B.C.
Steller's Jay	6	X	X	X	X		all Van Is	southern 1/3 of B.C.
Townsend's Warbler	6	X	X		X		all Van Is	all except NE corner
Cooper's Hawk	7	X					Nanaimo south	southern 1/3 of B.C.
Northwestern Crow	7	X	X				all Van Is	coast
Pileated Woodpecker	8	X	X				all Van Is	NE and S 1/2 of B.C.
Downy Woodpecker	8	X	X				all Van Is	all B.C.
Western Screech-Owl	9	X	X				all Van Is	SW 1/4 of B.C.
Tree Swallow	9	X	X	X			all Van Is	all B.C.
Chestnut-backed Chickadee	9	X	X				all Van Is	coastal B.C.; S Central B.C.
Belted Kingfisher	10	X	X	X	X		all Van Is	all B.C.
Fork-tailed Storm-Petrel	11	X			X		west coast	QC Str.; coastal QCI
Pelagic Cormorant	11	X	X		X		coastal areas	coastal B.C.
Black Oystercatcher	11	X			X		coastal areas	coastal B.C.

[a] Data summarized from Table 4.
[b] Description from Godfrey (1966).

1. Three subspecies are unique to Vancouver Island.
   White-tailed Ptarmigan Lagopus leucurus saxatilius Cowan
   Hutton's Vireo Vireo huttoni insularis Rhoads
   Northern Pygmy-Owl Glaucidium gnama swarthi Grinnell

2. In Canada several species breed only in British Columbia.
   Band-tailed Pigeon - only breeds west of the Rockies.
   Hutton's Vireo - breeds only in SW B.C.
   Black Oystercatcher - breeds only along coast of mainland, Queen Charlotte Islands and Vancouver Island.
   Vaux's Swift - breeds only in B.C.

3. Several species breed in densely concentrated breeding colonies: some with a restricted distribution.
   Great Blue Heron
   Seabirds (i.e. Fork-tailed Storm-Petrel, Leach's Storm-Petrel, Double-crested Cormorant, Brandt's Cormorant, Pelagic Cormorant, Glaucous-winged Gull, Common Murre, Rhinoceros Auklet, and Tufted Puffin) concentrate on offshore islands or along the coast.

4. Changes (additions and reductions) in breeding distributions have occurred.
   Addition: Bushtit - first record 1945.
   Common Barn-Owl - first record 1969.

   Reduction: Lewis' Woodpecker - last record 1961.
   Purple Martin
   Western Bluebird
   Yellow-billed Cuckoo - last record 1904.
   Downy Woodpecker
   Hairy Woodpecker
   Red-necked Grebe

5. Breeding distribution unknown

Marbled Murrelet - unlike other alcids this seabird is thought to nest inland; large feeding populations on coastal waters indicate substantial populations, but nesting habitat and distribution remain unknown. A recent review of known nest sites suggests that this species is a ground nester (Day et al. 1983). No data from Vancouver Island were used in the review.

Analysis of the nest record data resulted in three general observations concerning breeding bird distribution data.

1. There is a tremendous disparity among bird species in the quantity of available data.
2. Documentation (via sight records) to support species' distributions described (in literature) is lacking for most species.
3. Of the representative species chosen as lifeform examples, none were recorded in the Mountain Hemlock Zone.

Although it is difficult to know whether the disparities reflect lack of information or just restricted distribution, it is unlikely that the lack of nest records for the Mountain Hemlock Zone reflects an absence of breeding birds. It is suggested, therefore, that the disparities exemplify the paucity of the data available on Vancouver Island breeding bird distribution.

8 NUMBERS

Population estimates of the bird species that breed on Vancouver Island are few (Table 6). Of the few surveys conducted, the major focus has been on seabirds and raptors. With their inception in 1958, seabird surveys have been conducted the longest (Campbell pers. comm.). Information on distribution and numbers of seabirds has been compiled and are represented on the map, "Sea-bird Colonies of the Vancouver Island Area" (Campbell 1966). Raptorial bird surveys have been conducted on the Bald Eagle, Peregrine Falcon, Cooper's Hawk, and Common Barn-Owl. Most began in the early 1970's and have been conducted by several agencies (Wildlife Branch, CWS, BCPM, falconers) with

TABLE 6. Population estimates of some Vancouver Island breeding bird species

NOTE: For each species, the number listed is the population estimate for B.C., Ministry of Environment and Parks Region 1, or Vancouver Island.

Species	Population Estimates	
Canada Goose[1]		
Mixed races	approx. 250 pr. on Van. Is.	
Ducks[2]		
Mallard	735 000 in B.C.	
Wood Duck	5000 in B.C.	(Estimated total of
Harlequin Duck	8500 in B.C.	102 000 breeding
Hooded Merganser	5000 in B.C.	ducks on Van. Is.)
Common Merganser	73 000 in B.C.	
Upland Game Birds[3]		
Blue Grouse	200 000 in Region 1[a];	25% of B.C. pop'n.
Ruffed Grouse	100 000 in Region 1[a];	3% of B.C. pop'n.
Ptarmigan[b]	15 000 in Region 1[a];	1% of B.C. pop'n.
Band-tailed Pigeon	3500 in Region 1[a];	39% of B.C. pop'n.
Common Snipe	1500 in Region 1[a];	2% of B.C. pop'n.
Sea-Birds[4]		
Fork-tailed Storm Petrel	405 breeding pr.[c]	
Leach's Storm Petrel	12 450 breeding pr.[c]	
Brandt's Cormorant	72 breeding pr.[c]	
Double-crested Cormorant	576 breeding pr.[c]	
Pelagic Cormorant	2307 breeding pr.[c]	
Glaucous-winged Gull	12 020 breeding pr.[c]	
Common Murre	2633 breeding pr.[c]	
Pigeon Guillemot	944 breeding pr.[c]	
Tufted Puffin	23 128 breeding pr.[c]	
Rhinoceros Auklet	10 650 breeding pr.[c]	
Cassin's Auklet	100 325 breeding pr.[c]	

TABLE 6. Population estimates of some Vancouver Island breeding bird species cont'd.

Species	Population Estimates
Raptors	
Bald Eagle[5]	4073 ± 32% from Cape Caution south (adults-coastal)
Peregrine Falcon[6]	20 pr. on Van. Is. and offshore islands
Cooper's Hawk[6]	50 pr. on Van. Is.
Common Barn-Owl[6]	6 to 10 pr.; approx. 25 birds on Van. Is.
Others	
Great Blue Heron[7]	200 pr.; 6 to 8 heronries (4 on Van. Is.)
Black Oystercatcher[6]	400 pr. on B.C. coast

[a] Numbers reported as "rough estimates with wide limits".
[b] Includes all three species; only subspecies L. saxiatilus on Van. Is.
[c] Number of pairs calculated for coastal Van. Is. and its offshore islands only.

Sources:

1 Munro, pers. comm. (B.C. Ministry of Environment, Wildlife Branch, Victoria).
2 Preliminary Duck Management Plan for British Columbia (B.C. Ministry of Environment 1981b).
3 Preliminary Upland Game Bird Management Plan for British Columbia (B.C. Ministry of Environment 1980).
4 Sea-bird Colonies of Vancouver Island Area (Campbell, R.W. 1976).
5 Bald-eagle breeding population survey of coastal British Columbia (Hodges et al. 1984).
6 Campbell pers. comm. (BCPM, Vertabrate Zoology Division, Victoria).
7 Great Blue Heron colonies in British Columbia (Forbes et al. 1983).

varying degrees of continuity. Also, Great Blue Heron surveys (Forbes et al. 1983) and a freshwater lake breeding waterfowl survey have been conducted since 1973 (Campbell pers. comm.). The freshwater lake survey is progressing from the south to the north end of the Island: in summer of 1981 the Port Alberni-Qualicum area was surveyed (Dawe pers. comm.). Probably the best known and most widespread is the North American Breeding Bird Survey, initiated in 1966. This survey offers information on changes and trends in population of birds, particularly small land species (Erskine 1978).

Population estimates presented in the Preliminary Wildlife Management Plans for B.C. are based on habitat classification information and harvest data (B.C. Ministry of Environment 1980 and 1981b). Upland game bird numbers are for the Fish and Wildlife Vancouver Island (Region 1) management area (includes Vancouver Island and part of southwestern coastal mainland). For Vancouver Island, the estimated breeding duck population of 102 000 birds is 6% of B.C.'s population (B.C. Ministry of Environment 1981b).

9 HABITAT REQUIREMENTS

9.1 Introduction

In the early 1960's, the works of the MacArthurs' (MacArthur and MacArthur 1961, MacArthur et al. 1962) led one of the dramatic advances in bird ecology in the past three decades. These works, concomitant with their focusing of the role of vegetation structure on bird habitat selection, postulated that foliage height diversity (MacArthur and MacArthur 1961) and patchiness (MacArthur et al. 1962) were the factors controlling bird species diversity. In the ensuing years -- along with the support (Karr and Roth 1971, Thomas 1979, Cody 1981) and criticism (Willson 1974, Gauthreaux 1978) afforded any new paradigm -- attention focused on identifying and qualifying the attributes of the vertical and horizontal components of the vegetation structure responsible for habitat selection and the resultant bird species community

(Roth 1976, Conner and Adkisson 1977, Franzreb and Ohmart 1976, Robbins 1978, James and Warmer 1982, Rice et al. 1984). While this information was primarily directed at the community, lifeform, or guild level, interest in the role of spatial heterogeniety on habitat selection at the species level also increased substantially (Thomas 1979, Reynolds 1983). Just as, in its time, the initial work of MacArthur and MacArthur (1961) successfully predicted bird species diversity using vegetation structure components, this later information has become useful in demonstrating and predicting the habitat requirements of a species or lifeform.

9.2 Method

Species with similar life requisites were grouped into 11 lifeforms representing the 139 breeding bird species that are known or suspected to breed on Vancouver Island (Appendix 1). Lifeforms descriptions and their corresponding species are listed in Appendix 2. Because of the number of species involved, species within each lifeform were selected to represent the habitat requirements characteristic of the lifeform and the range of variation within the lifeform (Campbell pers. comm.). The number of these representative breeding bird species within each lifeform ranged from one to three and are denoted by an asterisk (*) in all species lists. In the initial approach, information was compiled on only the representative breeding bird species, to reduce the volume of material reviewed but still allow inferences to be made about the lifeform. It became apparent, however, early in the analysis that information on many of the species was scanty (and for some entirely lacking), thereby making even preliminary discussion and conclusions difficult. Consequently, the review was expanded to include available information on many species within each lifeform.

Several formats are used to present the information compiled for the analysis. Life history information for the representative breeding bird species in each lifeform is summarized in Appendix 3. Tables featuring species use of community components (e.g. rivers, edges, snags) and forest successional stages are presented (Appendix 4 and 5, respectively). Forest

successional stages follow Thomas' format (1979) and include: grass/forb, shrub/seedling, pole/sapling, young, mature, and old growth. Figures illustrating species orientation to these forest successional stages for feeding and reproduction, in terms of percent species use, are also presented (Figure 2 in Section 9.14)[1]. Percent species use was calculated from the information provided in Appendix 5 and is listed in Appendix 6. The text discusses the interrelationships of these habitat variables to the feeding and reproductive requirements of the lifeform and, as well, provides species-specific information to illustrate the range of these habitat needs. Following the text, a point-form synopsis of the general habitat requirements for the lifeform and the specific requirements of some species within the lifeform are given.

9.3 Lifeform 1: REPRODUCES near or on water.
FEEDS on ground; in shrubs, trees and water.

Common Loon, Bald Eagle, Spotted Sandpiper

Water is the principal habitat component grouping these species (Appendix 4). All species nest on, above, or near (adjacent to or within commuting distance of) water and most (e.g. waterfowl, coots, grebes, gulls, fish-eating raptors) depend on the aquatic medium for their principal food source. Both inland and coastal waters are used.

For species that nest on or along the shoreline of freshwater lakes or marshes, emergent and riparian vegetation (e.g. cattails, sedges, willows) are necessary features of their habitat (Appendix 4). It provides the required nest substrate or nesting construction material while affording climatic protection and visual protection from predation (Schranck 1972) and disturbance (Jackman and Scott 1975). Coots and grebes favour water bodies

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[1] Figures are presented together to allow comparisons between lifeforms and successional stages (pgs. 52 and 53).

where emergent vegetation of medium density is adjacent to open water (Weller and Spatcher 1965). Landin (1979) describes "deep fresh marsh" (depth 0.2-1.0 m) as the most valuable habitat for waterfowl and very important for loons, grebes and coots, and "shallow fresh marsh" (depth less than 0.2 m) as a very important nesting and feeding habitat for the Virginia Rail, Sora, American Coot, Common Snipe, Spotted Sandpiper and Red-winged Blackbird. Weller and Spatcher (1965) found maximum marsh bird numbers and diversity were reached when a well-interspersed 50:50 cover:water ratio occurred. On Vancouver Island, the freshwater marsh habitat is very limited (Campbell pers. comm.).

Feeding requirements for most of these species are generally satisfied within their nesting habitat. Aquatic vegetation is the major food item for dabbling ducks and other nesting waterbirds (Landin 1979). At breeding time, aquatic insects and invertebrates become an important food item in the diet of dabbling ducks (Wetmore pers. comm.). Shorebirds feed in a variety of situations. Killdeer forage along moist mudflats, either fresh or tidal, which will provide suitable habitat for their invertebrate prey (i.e. insects, molluscs, small crustaceans, worms). The Common Snipe feeds in marsh situations, the Spotted Sandpiper in the uplands (Campbell pers. comm.).

Tree-nesting species (Great Blue Heron, Osprey and Bald Eagle) typically require the stand characteristics of mature and old growth coniferous forests to provide suitable nesting sites (Corr 1974, Lehman 1979, Hodges et al. 1984). The limb structure and limb size of these trees provide the platform required to support the bulk and weight of the nest. For example, in their review of the Bald Eagle, Stalmaster et al. (1982) report that tree structure and its associated forest stands were more important nest site selection criteria than tree species composition. While some tree species selection does occur, this varies with geographic location and vegetative type of the region (Anthony et al. 1982). In coastal forests of western Washington and Oregon, Douglas-fir (70% and 84%, respectively) and Sitka spruce (17% and 12%, respectively) were used predominantly (Stalmaster et al. 1982).

Proximity of the nest tree to foraging habitat is also an important habitat selection criterion. In the USA, extensive Bald Eagle studies

indicate that most nest sites are located within 1.6 km of a large food-rich water source (Anthony et al. 1982). A breeding Bald Eagle population survey for coastal B.C reported that the highest Bald Eagle densities occurred not more than 25 km from the ocean or large straits (Hodges et al. 1984). Osprey require clear water which allows for visual location and pursuit of their fish prey (Jackman and Scott 1975) and will travel 3 to 5 kilometers to feed (Campbell pers. comm.). Great Blue Heron forage in shallows, mudflats, and similar moist situations (e.g. fields). Here small fish, insects, and invertebrates are consumed. Maximum commuting distance from their communal nest site to the foraging site has not been reported. Shoreline perch sites are also an important habitat component within Osprey and Bald Eagle feeding habitat. The Common Merganser nests on the ground or in tree cavities along a slow-moving waterway or standing water body; in B.C., a ground nest site is typical. The Harlequin Duck is a ground-nesting species and prefers to nest along a swift-moving river or stream.

Most species in this lifeform are sensitive to human disturbance, especially during the nesting period, and seek secluded or isolated nesting sites. Waterfowl and other water nesting species (e.g. loons, grebes) rely on dense cover (emergent or riparian vegetation) (Jackman and Scott 1975, Landin 1978), freshwater islands or remote locations to provide this requirement. The Common Loon is known to be particularly intolerant of disturbance, and remote freshwater lakes are important to its reproductive success (Robertson and Flood 1980). The Sandhill Crane, which traditionally nested in open areas where safety and security lay in its ability to see great distances, has, with the elimination of this habitat, become restricted to wet bushy areas for protection from predation and disturbance. The Great Blue Heron, Bald Eagle, and Osprey also prefer undisturbed nest sites. Stalmaster et al. (1982) concluded that Bald Eagle tolerance to human activity is affected by distance from the activity, duration (permanent), time of year (breeding), type of activity (logging), level of noise, and degree of visual shielding of the activity by surrounding vegetation.

In summary, the forest successional stage surrounding the aquatic zone does not limit nesting sites for water-nesting species within this lifeform (Figure 2a). In contrast, tree-nesting species are dependent on the later stages of forest succession (e.g. mature, old growth) to provide suitable nest sites. The location of their nesting habitat, with respect to their feeding habitat (i.e. juxtaposition), is critical.

General Habitat Requirements

Reproduction

- emergent and riparian vegetation (cattail, sedge, deciduous)
- tree nesting species: tree with a limb structure and size capable of supporting large, bulky nests
- low human disturbance

Feeding

- dabbling ducks: aquatic vegetation, aquatic insects and invertebrates at breeding time
- Osprey: clear, fish-stocked water bodies
- wading birds: mudflats, gradual sloping shoreline
- Bald Eagle, Osprey: shoreline perch trees

Special Habitat Requirements

American Dipper - permanent, swift-moving clear streams or rivers

Shorebirds (Killdeer, Common Snipe, Spotted Sandpiper) - open terrain (low grassland vegetation, sand-gravel) adjacent to water for nesting; wet margins for feeding

Great Blue Heron - groves of large isolated nest trees within commuting distance of water; minimal disturbance around nesting colonies from time of pair formation (February) to fledging (mid-July); shallow water shoreline or standing water for feeding

Bald Eagle - large limb coniferous trees (dbh greater than 170 cm) within 1.6 km of fish-rich, large water source

Osprey - large isolated nest trees; clear waterbody with surface swimming fish for foraging

References: Guiguet 1955a and 1958d, Weller and Spatcher 1965, Beebe, F.L. 1974, Jackman and Scott 1975, Stalmaster et al. 1982.

9.4 Lifeform 2: REPRODUCES in cliff, cave, rimrock, and/or talus.
FEEDS on ground or in air.

Peregrine Falcon

Cliffs, rock outcroppings and talus provide the principal nesting habitat for species within this lifeform (Appendix 4). The literature indicates, however, that the degree of dependency on this habitat varies among these species. The Black Swift is exclusively a cliff nester, preferring moist locations, and is often found nesting near a waterfall. Within their subalpine habitat the White-tailed Ptarmigan and Rosy Finch are found to nest only in the rock outcroppings. Ptarmigan usually select nesting sites adjacent to grass/forb - shrub associations (Verner and Boss 1980). On the islands off the northern mainland coast of B.C., Peregrine Falcons are reported to use abandoned Bald Eagle nests when cliff nesting sites are scarce or absent (Campbell et al. 1978). Cliff and Barn Swallows, notably the most adaptable species in this lifeform, frequent, in urban areas, nest sites that are structurally similar to wilderness sites (e.g. cliffs). Water locales that provide mud-gathering sites for nest building are required within the swallow's nesting habitat, but this habitat component is probably not limiting on Vancouver Island (Verner and Boss 1980).

While some nesting substrate diversity is apparent, one critical nesting habitat criterion common to most Lifeform 2 species is site isolation or freedom from disturbance. Human disturbance (harassment or encroachment) has been reported as the factor contributing to the decrease in the breeding distribution of the Peregrine Falcon (Campbell et al. 1978), Turkey Vulture, and Common Raven (Gabrielson and Jewett 1970). Cliff and Barn Swallows are the only species that this factor does not limit.

For most species, suitable foraging habitat is also provided within their nesting habitat. The Black Swift and the swallows are insectivorous, aerial feeders and food requirements are easily satisfied. The White-tailed Ptarmigan and Rosy Finch are ground foragers, and abundant food is found within the grass/forb associations of their alpine habitat. In contrast, the Turkey Vulture and Common Raven are aerial-searching feeders and require open terrain, which facilitates visual location, as foraging habitat. Unlike the other species within this lifeform, the Peregrine Falcon's presence is limited by the availability of its prey, seabirds. Nelson and Myres (1975) report that a decline in the Peregrine Falcon population on Langara Island resulted from an abrupt decrease in Ancient Murrelets (Synthliboramphus antiguus), their chief prey species on the island. Campbell et al. (1978) observed that even though cliff nest sites were scarce, when prey (i.e. seabirds) was abundant nesting Peregrine Falcons were present. These studies indicate that a stable food supply is the requirement most critical to the Peregrine Falcon.

For most species within this lifeform, forest succession has little or no influence on the nesting and feeding habitat requirements; the Peregrine Falcon is the exception (Figure 2b). Availability of the grass/forb stage of early forest succession used by many species as feeding habitat is probably not limiting.

General Habitat Requirements

Reproduction

- low human disturbance

Feeding

- open terrain (water bodies, forested or non-forested grass-forb association)

Special Habitat Requirements

Peregrine Falcon - small alcids or other small- to medium-size bird species, which fly over open areas such as water

White-tailed Ptarmigan - grass/forb - shrub association adjacent to subalpine rock outcropping

References: Gabrielson and Jewett 1970, Beebe, F.L. 1974, Nelson and Myres 1975, Campbell et al. 1978.

9.5 Lifeform 3: REPRODUCES on ground without specific water, cliff, rimrock or talus association.
FEEDS on ground; in shrubs, trees, or air.

Blue Grouse, Common Nighthawk, Savannah Sparrow

Species within this lifeform, grouped because of the ground nesting behaviour, select nesting sites within habitats of various vegetational associations (minimal or no vegetation, grass/forb, shrubbery) (Appendix 4 and Appendix 5).

The Horned Lark, Common Nighthawk, and Water Pipit are found in open habitats and select nest sites in areas with minimal or no vegetation (Appendix 4). The Common Nighthawk selects a nesting substrate such as sand, gravel, or flat rock, where protection from predation is provided by the similarity of the egg colouration to the substrate. In contrast, the Water Pipit obtains nest concealment and shelter by locating it under or at the base of a rock or under an earthen overhang.

Species nesting in a grass/forb association include Blue Grouse, Short-eared Owl, Western Meadowlark, and Savannah Sparrow (Appendix 5). Of

these species, Western Meadowlark, Savannah Sparrow and to a lesser extent the Short-eared Owl prefer nesting in open, dry grasslands. In contrast, Blue Grouse exploit this homogeneous habitat type very little (Mussehl 1963), preferring areas with a more diverse vegetation structure. On Vancouver Island this species has been the focus of extensive research (e.g. Fowle 1960, Bendell and Elliot 1966, Zwickel 1966, Armleder 1980, Frandsen 1980) and the information available indicates that Blue Grouse habitat requirements are complex and related to vertical and horizontal vegetation cover. The literature reports that habitat requirements of Blue Grouse males include open areas for courtship and mating, elevated ground or trees for hooting, and vegetation clumps (trees or bush) for escape cover. Female Blue Grouse use the sheltered or protected area that is provided by a log or low tree branch as their nesting site. Broods during their first weeks (4-6) require vegetation with an effective height of 20 cm; as the brood matures, densely vegetated areas and woody cover become increasingly more important. Young Blue Grouse feed on insects and it is likely that type of cover preferred has some relationship to the insect density and availability (Munro pers. comm.). Hens and their broods prefer areas of low canopy cover within 15 m of shrubs or trees that provide escape cover (Bendell and Elliott 1966, Armleder 1980). Roost trees are also an important component of Blue Grouse habitat. Johnson (1929, cited in Jackman and Scott [1975]) reported that they generally roost 2.5 m from the trunk and 3.7-9.2 m above the ground. Unfortunately, variables such as foliage density, branch diameter, and branch height limits (maximum, minimum) were not reported at these site locations. However, foliage shelter is assumed to be critical. In general, open conifer stands with a horizontal tree cover of less than 50% and a vertical cover of coniferous trees (2.5-5.5 m) or dense, heterogeneous herbaceous vegetation (minimum effective height of 20 cm) provide the open, hot, dry habitat and complexity necessary for breeding Blue Grouse. Blue Grouse migrate seasonally a maximum distance of 16 km (10 m) (Bendell and Elliot 1966) between their coniferous, upland winter range and their lowland breeding summer range. Most species in this sub-group

nest exclusively in the grass/forb stage of forest succession; Blue Grouse nesting habitat is provided until the pole/sapling stage (Appendix 5).

Species nesting beneath the protective shrub canopy include the Ruffed Grouse, Hermit Thrush, Orange-crowned Warbler, Wilson's Warbler and Rufous-sided Towhee. All of these nest in riparian-shrub associations (Appendix 4) in varying stages of forest succession (Appendix 5). Upland shrub habitats are also used. Some prefer the concealment of dense shrubbery (e.g. Orange-crowned Warbler, Rufous-sided Towhee), while others (e.g. Wilson's Warbler) prefer a more open shrub structure. All except the Hermit Thrush occur in the shrub/seedling or pole/sapling stage of forest succession. This species uses the lower stratum of only the oldest stages (mature and old growth) of forest succession.

Also included in this lifeform is the Marbled Murrelet. Its inclusion is based primarily on a review and analysis by Day et al. (1983). These authors found that most nests (seven of nine) were on the ground, located on substrates with 0 (bare rock) to 100% vegetation cover, at a mean elevation of 304 m, and a mean distance from the sea of 6.0 km. Ground nest site locations reported include burrows, rock crevices, open river gravel, bare lava, and forest floor (in heavy grass and among the trees) (Guiguet 1972, Day et al. 1983). In B.C., a Marbled Murrelet nest has still not been discovered but information suggests that this species nests on the ground as well as in trees in this province (Guiguet 1972). The only record of this species on Vancouver Island reported the discovery of a two young murrelets in a tree after felling (Harris 1971). Because data are few and quite variable, there is yet to be a consensus on Marble Murrelet nest site location. Tree nesting is gaining credence however, especially in areas such as Vancouver Island where old growth forest lines the coast (Guiguet 1978, Sealy and Carter 1984). With the likelihood that the Marbled Murrelet is a tree nesting species on the coast, there is an increasing need to determine if old growth trees are required.

Just as this group of ground nesting species uses habitats with various vegetative associations for their reproduction, this lifeform displays a variety of foraging behaviours. Many satisfy their feeding requirements

within their nesting habitat; however, some require forest successional stages (Appendix 5) and habitat components (Appendix 4) exclusive from those used for their reproduction (e.g. Marbled Murrelet, Common Nighthawk, Horned Lark, Water Pipit, Wilson's Warbler). Grass/forb habitat, water bodies, and water courses provide the open areas required by aerial foraging insectivores (e.g. Common Nighthawk). The Short-eared Owl, the only raptor (diurnal), hunts exclusively in a grass/forb habitat, where mice, which make up 75%-90% of its diet, are found (Guiguet 1978). Bird species feeding in the shrub/seedling and older stages of forest succession (Appendix 5) require herbaceous and shrub vegetation to provide seeds, fruit, an insect-gleaning substrate, and foraging cover. On Vancouver Island, important summer dietary items for Blue Grouse include: bracken fern (Pteridium aquilinum); willow fruit buds and leaves (Salix spp.); Oregon grape (Mahonia spp.), blackberry (Rubus vitifolius), huckleberry (Vaccinium spp.) and salal fruit (Gaultheria shallon); and cat's ear buds (Hypochaeris radicata) (Fowle 1960).

Most species in this lifeform (64%) use the grass/forb stage for feeding (54%) and reproduction (54%) (Figure 2c). As forest succession advances, species use decreases.

General Habitat Requirements

Reproduction

- variety of cover vegetation types, from open with minimal vegetation to dense shrubbery (see text)

Feeding

- elevated perches
- open areas
- berry-producing shrubs and trees

Special Habitat Requirements

Blue Grouse - open areas for courtship and mating; elevated ground or trees for hooting; minimal vegetation height of 20 cm for nesting and chick cover

Hermit Thrush - singing perches; mature or old growth stands for nesting

Wilson's Warbler - open riparian shrubbery for nesting

Rufous-sided Towhee - dense shrubbery with an accumulation of ground leaf litter

References: Guiguet 1955, Guiguet 1960, Mussehl 1963, Guiguet 1964, Bendell and Elliot 1966, Guiguet 1972, Clark 1975, Guiguet 1978, Armleder 1980, Frandsen 1980.

9.6 Lifeform 4: REPRODUCES in shrubs.
FEEDS on ground; in shrubs, trees, or air.

Yellow Warbler, Fox Sparrow

Shrubs provide the nesting substrate for species of this lifeform. Nests are typically between 0.5 and 2 m above ground, although ground nests and nests 6 m above ground have been reported (Guiguet 1964, Godfrey 1966, Gill et al. 1974, Roe 1974, Guiguet 1978). The shrub ecotone characteristic of grassland and forest edges is a habitat component occupied by the majority of these species (Appendix 4). Shrubs found in moist areas -- riparian and upland -- provide the preferred habitat of many and the exclusive habitat of some (e.g. Eastern Kingbird). Throughout the transition from the development of the shrub layer to conifer dominance (shrub/seedling to young stage) suitable nesting habitat is provided for all species (Appendix 5). During this period, species communities overlap and densities vary as the shrub layer develops from open and patchy (e.g. American Goldfinch, Dark-eyed Junco) to dense and ubiquitous (e.g. Swainson's Thrush, Fox Sparrow).

For the majority of the species in this lifeform, feeding requirements are provided within their nesting habitat (Appendix 5). Initial occupancy in the grass/forb stage of succession is by seed eating species such as the American

Goldfinch, White-crowned Sparrow and Dark-eyed Junco. The developing shrub layer provides the required foraging substrate for insect gleaners (e.g. Yellow and MacGillivray's Warbler) and cover for ground foraging species (e.g. Fox and Song Sparrow). As the shrub density increases, preferred feeding habitat of the Swainson's Thrush is created. Elevated perches required by aerial foraging insectivores (e.g. Eastern Kingbird, Willow Flycatcher) become available as conifers dominate the stand.

Most species in Lifeform 4 occur in the shrub/seedling to young stages of forest succession (Appendix 5). The maximum number of species use the shrub/seedling stage for feeding (93%) and the pole/sapling stage for nesting (100%) (Figure 2d). Both activities decrease as forest succession advances, and reach a level of less than 40% species use by the mature stage.

General Habitat Requirements

Reproduction

- edge habitats between grasslands, forests, and/or shrub fields (less than 3 m tall)
- riparian or moist upland shrubs

Feeding

- shrubs: insect-gleaning substrate, ground foraging cover
- elevated perches: insectivorous aerial foragers

Special Habitat Requirements

Rufous Hummingbird - nectar source; also feed on flying insects

Bushtit - semi-open Garry Oak - Ocean Spray (Quercus garryana - Holodiscus discolor) habitat

Brown-headed Cowbird - parasitic nester; warbler, vireo, finch, flycatcher or thrush provide host nest

Dark-eyed Junco - ground debris (e.g. slash)

Song Sparrow - dense but not high vegetation with exposed ground underneath

References: Horvath 1963, Tompa 1963, Guiguet 1964 and 1972.

9.7 Lifeform 5: REPRODUCES primarily in deciduous trees.
FEEDS in shrubs, trees, or the air.

Warbling Vireo, Black-headed Grosbeak

Deciduous trees are the primary nesting habitat component of this species group. They provide the preferred nesting sites for all species and the exclusive nest site for some (Hutton's Vireo, Warbling Vireo, Black-headed Grosbeak). Nest heights range from 1.2 m to 25 m, with most species nesting in the low to mid-canopy layer. The Warbling Vireo is a notable exception, nesting on the small, highest branches of the upper canopy. In west coast coniferous forests in the United States optimum breeding habitat of these species is described as (1) having an open canopy (cover less than 39%), (2) supporting a substantial shrub layer, and (3) ranging in stages of forest succession from pole/sapling (6.1-5.1 m) to mature (greater than 15 m) (Verner and Boss 1980). This description is in general agreement with the information available for Vancouver Island (Appendix 4 and Appendix 5).

Deciduous trees also provide suitable foraging substrate for most species. Vireos glean insects from the foliage and small twigs. Fruits, berries, and seeds are the major diet items of the Cedar Waxwing and Black-headed Grosbeak and are also a minor component for vireos. The varying seasonal distribution of the Cedar Waxwing is affected by abundance of their food supply (Verner and Boss 1980). The House Finch, strictly an urban bird on Vancouver Island (Campbell pers. comm.), also uses these food items in addition to foraging on grasses and forbs and on the ground. The Red-tailed Hawk is an opportunistic raptor foraging for small mammals, birds, and reptiles in vegetation adjacent to its nesting habitat rather, than exploiting

one particular type vegetation (Luttich et al. 1970); perch trees are also required.

From the pole/sapling to the mature stage, nesting and feeding habitat are provided for the majority of species in this lifeform (Appendix 5). The maximum number of species (88%) nest in the pole/sapling to mature stage of forest succession and feed in the the shrub/seedling to mature stage (Figure 2e).

General Habitat Requirements

Reproduction

- open (less than 39% canopy cover), pole/sapling (6.1-m tree height) to mature (greater than 15 m) forest, with a dominant deciduous tree component and a substantial shrub layer

Feeding

- fruit-, berry- or seed-producing trees
- perch sites

Special Habitat Requirements

Red-tailed Hawk - large trees for nesting, roosting and perching; adjacent open areas for foraging

Hutton's Vireo - dedicuous thickets

References: Luttich et al. 1970, Beebe, F.L. 1974, Jackman and Scott 1975.

9.8 Lifeform 6: REPRODUCES primarily in conifers.
FEEDS in shrubs, trees and the air.

Western Flycatcher, Steller's Jay, Townsend's Warbler

Coniferous trees are the primary nesting sites for species within this lifeform (Appendix 4). While suitable nesting habitat is provided for some

species in the pole/sapling stage, the majority require mature or old growth stands to satisfy their nesting requirements (Appendix 5). Some species (Western Flycatcher, Townsend's Warbler, Olive-sided Flycatcher, Red Crossbill, Pine Grosbeak, Northern Goshawk) nest exclusively in these older seres (Roe 1974, Moore and Henry 1983, Reynolds 1983, Campbell pers. comm.). Although optimum canopy cover varies among these species, most prefer either an open or clumped forest stand structure. The Golden-crowned Kinglet (Edwards et al. 1962), Northern Goshawk (Moore and Henry 1983, Reynolds 1983), and Townsend's Warbler (Wetmore pers. comm.) are exceptions, preferring dense or continuous forest stands. For Northern Goshawk, overall stand appearance (e.g. tree density, height, canopy, presence of water) is the major factor influencing nest site selection: choice of nest tree is secondary (Hennessy 1978, Moore and Henry 1983, Reynolds 1983). Critical structural characteristics of Northern Goshawk nest sites are associated with old growth successional stands. Moore and Henry (1983) in eastern Oregon and Reynolds (1983) in western Oregon have detailed the structural characteristics of Northern Goshawk nesting habitat and are in general agreement with studies elsewhere (e.g. in Utah, Hennessy 1978). This species displays strong nest site fidelity (using nests for as long as 10 years) and appears to be less variable than other accipiters in its choice of nest site habitat structure. In Oregon, for example, stand characteristics include: density of 482 stems/ha, mean dbh of 22 cm, slope 14%; nest tree characteristics include: dbh of 52 cm, nest height 14 m, nest canopy coverage 88%, location within 200 m of water, northerly aspect, and preference for Douglas-fir and western larch (Moore and Henry 1983, Reynolds 1983). In addition, proximity to water, riparian, and edges are nesting habitat components associated with many species in this lifeform. Generally, the species information presented in this analysis agrees with that in the literature available for western coniferous forests elsewhere. Some regional differences have been observed for a few species on Vancouver Island, but findings are inconclusive (Roe 1974).

For all species, feeding habitat is also provided within their coniferous or mixed coniferous forest nesting habitat. Within this habitat, riparian and

forest edges are used by all species (Appendix 4). Perches (e.g. snags) are an important habitat component in the feeding habitat of insectivorous aerial foragers (flycatchers) and raptors (Northern Goshawk, Great Horned Owl). Conifer seeds are the staple food of the Red Crossbill and, due to this dependence on seed-bearing conifers, it is highly nomadic; this feeding requirement ultimately determining its nesting habitat selection. Feeding habitat for most species is provided in forest stands in the shrub/seedling stage and older (Appendix 5).

Forest stands in the young stage and older provide the feeding and nesting habitat requirements for the majority of species within this lifeform (Appendix 5). Species habitat use for nesting and feeding increases with conifer dominance in the forest stand and reaches its maximum (100%) in the mature stage (Figure 2f).

General Habitat Requirements

Reproduction

- large coniferous trees (greater than 6 m in ht.)
- presence of water, riparian habitat
- dense canopy foliage

Feeding

- perch trees
- riparian or forest edges

Special Habitat Requirements

Northern Goshawk - continuous conifer or mixed conifer, old-growth forest, dense canopy cover

Western Flycatcher - conifer or mixed conifer forest in moist (stream, seep, spring) area for nesting; perches

Golden-crowned Kinglet - dense canopy

Red Crossbill - abundant cone crop

References: Horvath 1963, Beebe, F.L. 1974, Roe 1974, Scoullar 1980.

9.9 Lifeform 7: REPRODUCES in conifers or deciduous trees.
FEEDS on the ground; in shrubs, trees or the air.

Cooper's Hawk, Northwestern Crow

All species within this lifeform are tree nesters, but there appears to be no preference for either coniferous or deciduous trees. Common to most, however, is their association with the vegetation types of moist areas. Riparian zones are used by many species as nesting habitat (Appendix 4). The Northwestern Crow and American Robin, two very adaptable species, nest in various riparian and urban situations. The Varied Thrush prefers forest types associated with high soil moisture (Scoullar 1980). The Cooper's Hawk and the Band-tailed Pigeon require a permanent water source within the nesting habitat (Jackman and Scott 1975). Dense forest stands are preferred by Cooper's Hawk, Varied Thrush and Evening Grosbeak. For Cooper's Hawk, critical nest site characteristics are structural features typically associated with young stands (40-70 yr) (Moore and Henry 1983, Reynolds 1983). In Oregon, these include: density of 907 stems/ha, mean dbh of 15 cm, and slope 17%; nest tree characteristics include: dbh of 44 cm, nest height 12 m, nest canopy coverage 95%, a preference for Douglas-fir, a nest substrate of mistletoe mass, location within 475 m of a permanent water source, and a northly aspect (Moore and Henry 1983, Reynolds 1983). For the Band-tailed Pigeon, stand density and tree composition are important nesting habitat criteria (Keppie 1970, cited in Jackman and Scott 1975). Mixed coniferous forests (Douglas-fir, oak, alder) with light to medium densities are preferred by this species, although in stands of densely stocked Douglas-fir (15 years +), taller scattered trees are required. Nesting habitat for most of these species is provided in the pole/sapling and young stages of forest succession; Merlin, Band-tailed Pigeon

and Northwestern Crow nest exclusively in these stages (Appendix 5). Mature and old growth stands are exclusive nesting habitats of the Evening Grosbeak and Western Tanager.

Although food requirements are generally satisfied within the species nesting habitat, several species also use additional successional stages (Appendix 5) and habitat components (Appendix 4) to satisfy foraging needs. For example, feeding requirements include perch trees for Merlin and Cooper's Hawk. For the Band-tailed Pigeon, a food source of fruits, berries, flowers or seeds is required near its nest site (Jackman and Scott 1975). The Varied Thrush's preference for foraging in the lower stratum, especially the forest floor, is suggested to have some relationship to high soil moisture and insect densities (Scoullar 1980). For most species, forest edges and riparian zones are also important habitat features.

Species numbers are highest throughout the development of the conifer canopy from the shrub/seedling (89%) to the young (100%) stage (Appendix 5). Maximum species numbers for feeding (100%) occur in the pole/sapling stage and for reproduction in the young stage (89%) (Figure 2g).

General Habitat Requirements

Reproduction

- dense stand structure and canopy cover
- moist area vegetation types, riparian

Feeding

- vegetation types associated with moist upland and riparian areas
- forest edges; above canopy trees

Special Habitat Requirements

Cooper's Hawk - dense stand structure (30-70 years old) with a northerly aspect; permanent water source; perch trees

Band-tailed Pigeon - nest trees close to water source for daily drinking; tall trees above canopy for "cooing" males; food source of berries, fruits or seeds near nest site

Northwestern Crow - roost trees

Varied Thrush - dense forest types associated with high soil moisture

References: Guiguet 1954, Beebe, F.L. 1974, Jackman and Scott 1975, Scoullar 1980, Moore and Henry 1983, Reynolds 1983.

9.10 Lifeform 8: REPRODUCES in excavated cavity in tree.
FEEDS on the ground or in trees.

Pileated Woodpecker, Downy Woodpecker

Species within this lifeform excavate their nest cavities and are known as primary cavity nesters. Literature on cavity nesting species is extensive (e.g. Kelleher 1963, Thomas et al. 1979) and concludes that the habitat component limiting population densities is the availability of suitable nest trees (Beebe, S.B. 1974, Bull 1975, Jackman and Scott 1975, Scott and Patton 1975, McClelland 1977, Davis et al. 1983, Raphael and White 1984, and others). Of the many tree characteristics analysed, the decay condition of the tree -- i.e. soft heartwood and sound sapwood -- is the major factor contributing to a tree's suitability (Conner et al. 1976, McClelland 1977, Conner 1978, Stauffer and Best 1980, Allaye-Chan 1981). This combination provides the substrate suitable for excavation (soft heartwood) and the protection from predation and weather (sound sapwood). Both live culls (deteriorating and deformed trees) and snags (dead trees) are used. Snags provide the most suitable nesting sites and are consequently used by all woodpecker species and exclusively by some (Appendix 4). The literature is conclusive about the importance of snags as the nesting habitat requirement limiting woodpecker populations.

Woodpeckers identify the presence of heartwood rot by the resonance produced during pecking (Conner et al. 1976). The type of decay (i.e. pathogen) determines which portion of the tree is infected (pathogen dynamics), and ultimately determines which tree species will be used by woodpeckers. Certain species (aspen [Populus tremuloides], ponderosa pine [Pinus ponderosa], and western hemlock [Tsuga heterophylla]) appear to provide these characteristics more readily than others (Douglas-fir [Pseudotsuga menziesii], grand fir [Abies grandis], lodgepole pine [Pinus contorta], and western redcedar [Thuja plicata]), although studies indicate regional variations (Miller and Miller 1976, Mannan et al. 1980, Allaye-Chan 1981). In the Chemainus area of Vancouver Island (CWH, dry subzone), Allaye-Chan (1981) observed that use of western hemlock snags by primary cavity nesters was disproportionately high compared to the tree species' occurrence. She correlated this preference to the high incidence of trunk rot infection occurring in this species. Many studies from other areas have concluded that broken top snags are preferred by cavity nesters but Allaye-Chan's data to not support this conclusion. This illustrates the need for specific regional information on the interrelationship between tree species and pathogen dynamics in B.C. coastal forests.

Nest tree suitability is also dependent upon tree size. Tree height and dbh are the typical measurements used to characterize nest trees, and the literature generally agrees that large mature and old growth trees are usually selected. The tree diameter necessary to provide the cavity size required is a function of the size of the cavity nester. Several authors have reported dbh and tree height dimensions for cavity nesters in their area (e.g. Bull 1975, McClelland et al. 1979, Thomas et al. 1979, Raphael and White 1984), and a review of this literature indicates that regional variations occur within species. Many quote minimum dimensions as nest tree guidelines (e.g. Thomas 1979). In coastal forests of southeast Vancouver Island (CWH, dry subzone), Allaye-Chan (1981) found that the mean height and dbh were, respectively, 17.9 m and 55.7 cm (min 37.0 cm) for the Downy Woodpecker, 23 m and 65.5 cm (min. 33.7 cm) for the Red-breasted Sapsucker and Hairy Woodpecker, and 28.8 m

and 60.2 cm (min. 47.2 cm) for the Northern Flicker and the Pileated Woodpecker. Conner (1979) cautions against using minimum standards as management guidelines and suggests mean height and dbh dimensions be used as the nest tree requirement standards. He further suggests that nesting habitat should include trees that span these dimensions to maximize breeding success.

All but the Northern Flicker and Red-breasted Sapsucker excavate a new cavity each year (Thomas 1979). The same tree can be used in consecutive years, but a case of more than one species using the same nest tree is rare, occurring only in very large trees (mean dbh 2 m, mean height 13 m) and when the snag density is low (Miller and Miller 1976). Roosting cavities are also required, and although old nest cavities can be used, roosting and nesting cavities do not occur in the same tree. In addition, drumming and perch trees are required, as are separate roosting cavities for the male and female of the breeding pair. Because of the territorial requirements, most species need an even distribution of snags to maximize their breeding density (Thomas et al. 1979). The Pileated Woodpecker and Three-toed Woodpecker are exceptions, preferring to nest in areas where snags are clumped together (Jackman 1974, Bull 1975).

Stauffer and Best (1980) found that in riparian habitat the minimum, mean widths of the forested area necessary to support a breeding population of Downy and Hairy woodpecker are 15 m and 40 m, respectively. Minimum nesting territory for the Pileated Woodpecker in northeastern Oregon is 130 ha (320 acres) (Bull and Meslow 1977). In the Blue Mountains of northwestern Oregon and Washington, territory sizes for these species are 4 ha (10 acres), 10.1 ha (25 acres), and 121 ha (300 acres), respectively; and 16.2 ha (40 acres), 4 ha (10 acres), and 30.4 ha (75 acres) for the Northern Flicker, Red-breasted Sapsucker, and Three-toed Woodpecker, respectively (Thomas et al. 1979).

Insects comprise the major food item in the diet of most woodpeckers. Living (trunk, branches, twigs), dead (snags) and dying trees provide suitable foraging substrates for most species. The Three-toed Woodpecker prefers scaly barked trees such as spruce, hemlock, and lodgepole pine (Jackman 1974). This species feeds primarily on wood-boring beetles and the density and duration of

the species in an area is thought to be dependent on food supply (Taylor and Barmore 1980). These authors found that severly burned areas have high densities of short duration (less than 2 years); moderate burns have lower but more stable densities, with the species remaining, at most, 5 years. They concluded that the Three-toed Woodpecker is dependent upon forest fires to create their habitat. Pileated Woodpeckers feed mainly on carpenter ants and require habitats that contain high densities of snags and logs greater than 18 cm in diameter, dense canopies, and tall shrub cover; areas with downed material covering 10% of the ground are preferred (Bull and Meslow 1977). Downy and Hairy woodpeckers, in addition to excavating, glean insects from tree trunks, branches and twigs. The Red-breasted Sapsucker feeds on the tree sap of both conifer and deciduous trees; the latter tree type seems to be preferred. The feeding habitat requirements of most are satisfied within each species' breeding habitat. One exception is the ground-feeding Northern Flicker. This species' selection of a nest tree adjacent to open foraging habitat (i.e. grass/forb) is equally important as its selection of a suitable nest tree (Hardin and Evans 1977).

Other habitat variables selected for, or highly correlated with, woodpecker occurrence include: conifers (Pileated, Three-toed); deciduous trees (Downy, Red-breasted Sapsucker); dense canopy (Pileated); density of subcanopy (Downy); and open or semi-open forest (Downy, Northern Flicker, Hairy, Three-toed).

Maximum woodpecker species numbers (100%) are reached in the mature stage (Appendix 5). Nesting habitat is not suitable until the young stage; maximum species numbers are reached in the mature stage. For tree foraging woodpeckers[1], feeding habitat suitability increases with forest age and all occur in the young stage of forest succession.

Snag habitat management (dynamics, densities, species requirements) is the current focus of cavity nester research (Cline et al. 1980, Davis

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[1] Includes five of the six species in this lifeform; the Northern Flicker is a ground feeder.

et al. 1983). Resultant formulae (Bull and Meslow 1977, Bull et al. 1980) have enabled the calculation of required snag densities for a given woodpecker population (Thomas 1979), as well as the prediction of snag densities given the original snag density and annual felling rate (Cimon 1983, Menasco 1983, Raphael 1983). As yet, however, these models are still only theoretical and the need for field validation is timely and critical.

General Habitat Requirements

Reproduction

- trees with soft heartwood for excavating and sound sapwood for protection
- snags

Feeding

- dead (snags, logs, stumps) or dying (decaying with high insect densities) trees

Special Habitat Requirements

Northern Flicker - nesting snags in open or semi-open areas for ground foraging

Pileated Woodpecker - hard nest snag in snag cluster in dense mature coniferous forest; low human disturbance

Red-breasted Sapsucker - broken-top tree in advance stage of heartrot decay (Fomes primary pathogen)

References: Kelleher 1963, Beebe, S.B. 1974, Thomas et al. 1979, Allaye-Chan 1981, Davis et al. 1983.

9.11 Lifeform 9: REPRODUCES in hole made by another or natural cavity
FEEDS on the ground; in shrubs, trees, water or the air

Western Screech-Owl, Tree Swallow, Chestnut-backed Chickadee

Species within this lifeform depend on either natural cavity formation or the efforts of primary excavators (Lifeform 8, Section 9.10) to provide suitable nest sites. Accordingly, they are known as secondary cavity nesters and the literature concludes that the availability of suitable nest cavities is the major factor limiting species occurrence and population densities (McLaren 1962, Beebe, S.B. 1974, Holroyd 1975, Cunningham et al. 1980 [citing seven ref.], Scott et al. 1980). It is generally accepted that the increase in bird species diversity with stand age is due to the addition of hole-nesting species and has been correlated to the dynamics of snag production (Cline et al. 1980).

Nest cavity suitability for secondary cavity nesters has been characterized by many terms and measurements (Balda 1975, Miller and Miller 1976, Cunningham et al. 1980). Features most important to species selection include: (1) cavity entrance size, (2) inside cavity dimensions, (3) location, and (4) orientation of the cavity entrance. The requirements of entrance size and inside cavity dimensions are a function of the bird's dimensions, and consequently it is important to understand which primary excavators provide holes for the secondary cavity nesters. Several authors (Jackman 1974, Thomas 1979, Allaye-Chan 1981) have grouped secondary cavity nesting species with the primary excavators which typically provide a suitable cavity size. However, cavity use is not mutually exclusive, and generally small species (e.g. Red-breasted Nuthatch) are able to take advantage of a variety of cavity sizes by modifying entrance size and inside cavity dimensions (Beebe, S.B. 1974). Large species (e.g. Wood Duck, Hooded Merganser) are more limited by their size requirements. Cavity use by secondary cavity nesters is presented in Table 7. Included in this list are two species -- the Chestnut-backed Chickadee and Red-breasted Nuthatch -- which, in addition to using excavated or natural cavities, are able to excavate their own nest cavities. These

TABLE 7. Nesting cavities used by secondary cavity nesters

	Natural Cavity	Cavity Made by Another	Nest Boxes	Under Bark	Cavities Excavated by: Downy	Hairy	Red-breasted	Northern Flicker	Three-toed	Pileated	Chestnut-backed Chickadee[a]	Red-breasted Nuthatch[a]
Wood Duck	X	X	X					X		X		
Hooded Merganser	X	X						X		X		
American Kestrel[b]	X	X	X					X		X		
Common Barn-Owl[b]	X	X	X					X		X		
Western Screech-Owl[b]	X	X	X					X	X	X		
Northern Pygmy-Owl[b]	X	X	X			X	X	X	X	X		
Northern Saw-whet Owl[b]	X	X	X			X	X	X	X	X		
Vaux's Swift[b]	X	X								X		
Violet-green Swallow[b]	X	X	X		X	X	X	X			X	X
Tree Swallow[b]	X	X	X		X	X	X	X			X	X
Purple Martin	X	X				X	X		X			
Chestnut-backed Chickadee[b]	X	X			X							
Red-breasted Nuthatch[b]	X	X						X	X			
Brown Creeper[b]				X								
House Wren	X	X	X		X						X	X
Winter Wren	X	X			X						X	X
Bewick's Wren	X	X	X		X						X	X
European Starling (I)[b]	X	X	X			X	X	X	X			
House Sparrow (I)[b]	X	X	X		X					X	X	X

[a] Excavates cavity in soft or decaying wood.
[b] Also uses cavities for roosting.
(I) Introduced species.

Sources: Erskine and McLaren 1972, Jackman 1974, Thomas 1979, Scott et al. 1980, Allaye-Chan 1981.

species are termed weak excavators and require soft wood typically found in trees in advanced stages of decay.

Suitability of a nest cavity is also dependent on the location of the nest tree with respect to other habitat components (Appendix 4). Wood Ducks (Gilmer 1978) and Hooded Mergansers (Kitchen and Hunt 1969) require that their nest cavity be within 1 km (0.5 km is preferred) of a permanent water source. The Wood Duck prefers sloughs, backwaters, and lakes (or similar standing water body) with early emergent vegetation for food and protection in brood rearing. The Hooded Merganser nests along small, quiet woodland ponds, lakes, and slow-moving streams (Guiguet 1958, Campbell pers. comm.).

Cavities within open forest types are selected by the American Kestrel, Common Barn-Owl, Northern Pygmy-Owl, Tree Swallow, and Red-breasted Nuthatch. For the American Kestrel (Hamerstrom et al. 1973), Western Screech Owl (Ellison 1980), and Tree Swallow (Hardin and Evans 1977), nesting habitat selection is influenced equally by availability of a suitable nest cavity and location adjacent to suitable foraging habitat (open terrain, edges).

Orientation of the nest cavity entrance is also an important feature for some species. Cavity orientation towards a forest opening accommodates the flight pattern (undulating, swooping, erratic) of species such as the Violet-green Swallow and Tree Swallow as they fly to and from their nest cavity (Scott et al. 1980). Cavity orientation also influences the probability of initial discovery, as with the Wood Duck (Gilmer et al. 1978). Orientation to maximize light and warmth or to reduce exposure to weather (on the underside of a tree, facing downhill to the slope) has also been reported (Scott et al. 1980).

Other factors reported to affect the suitability of a nest cavity include: (1) presence of parasites (Miller and Miller 1976), (2) previous breeding success (Bellrose et al. 1964), (3) cavity height, and (4) protection from predation and weather. Minimum nest heights reported in the literature differ among authors. Even within a species, nest height varies considerably. It is suggested that nest height is mainly a function of the cavity's ability to provide protection from predation and insulation from the elements. For

example, McLaren (1962) found in his study area (Cariboo area in B.C.) that American Kestrel nests less than 5 m above ground were unsuccessful.

The major source of suitable nesting and roosting cavities, in addition to perch sites, foraging substrates, and drumming posts, are snags and cull trees (Cunningham et al. 1980, Miller and Miller 1980). The dependency of primary cavity nesters on snags and culls and the need for maintaining and providing these trees has been previously discussed (Lifeform 9, Section 9.10). Because of the consequent dependency of secondary cavity nesters on the availability of cavities created by primary excavators (or of naturally occurring cavities), the importance of this habitat component is compounded. Cunningham et al. (1980) found that snag density alone accounted for more than half the variability in density of secondary cavity nesters.

In this analysis, secondary cavity nesters did not display the general pattern of increased species numbers with advancing stand age. The highest number of secondary cavity nesting species occurred in the young stage (88%) and then decreased with advancing age of the stand (Appendix 5). However, most species do nest in the mature stage (82%) (Figure 2i). Emmett's (1983) study in the Coastal Western Hemlock Biogeoclimatic Zone on southwest B.C. mainland showed a similar nesting occurrence pattern. The changes in species habitat use for feeding throughout stand development showed no obvious pattern or concurrence with information from elsewhere (Meslow and Wight 1975, Thomas 1979, Emmett 1983). What was indicated, however, was that while stands in the young stage provide the nesting habitat components suitable for most species, some require mature and old growth stands for nesting (e.g. Vaux's Swift).

General Habitat Requirements

Reproduction

- available excavated or natural cavities with a entrance hole and cavity size of suitable inside dimensions to allow movement and space for clutch

- soft wood in advance stages of decay (Chestnut-backed Chickadee, Red-breasted Nuthatch)
- snags or cull trees

Feeding

- nest cavity within or adjacent to feeding territory (water or open areas)

Special Habitat Requirements

Wood Duck - nest cavity within 0.8 km of water; water body with emergent vegetation for brood rearing (feeding, protection)

American Kestrel - nest cavity adjacent to open terrain; elevated perches

Western Screech-Owl - protected daytime roosts (dense canopy or cavity); availability of water; forest edges; absence of large owl predators

Brown Creeper - snags with loose bark to nest behind; 200-year-old western redcedar, Douglas-fir, Sitka spruce trees

Chestnut-backed Chickadee - cavity in forest with dense upper story canopy; soft wood for excavation

Red-breasted Nuthatch - cavity or soft wood for excavation

Winter Wren - nest in lower forest stratum: most often in cavities of upturned tree roots, mosses on trees, etc.; ground litter; logs in dense tangle

References: McLaren 1962, Horvath 1963, Sturman 1969, Beebe, S.B. 1974, Jackman 1974, Van Camp and Henny 1975, Cunningham et al. 1980, Allaye-Chan 1981.

9.12 Lifeform 10: REPRODUCES in a burrow underground.
FEEDS in water or the air.

Belted Kingfisher

The two species that comprise this lifeform, Belted Kingfisher and Northern Rough-winged Swallow, require earthen banks in which to excavate their nesting burrows. Hamas (1975:12) describes the preferred nesting habitat of the Belted Kingfisher as "a nearly vertical bank of exposed soil and devoid of vegetation." When this natural habitat is limited, however, both species will use sites created by human disturbance (gravel pits, sanitary land fill, along road cuts), where features are similar to the natural habitat. In B.C., Erskine (1979) calculated that 75% of the recorded nest sightings for the Rough-winged Swallow were in natural sites. He further reported that colony size (x = 59 birds/colony) was higher in B.C. than elsewhere in Canada. Although only one pair of Belted Kingfishers will occupy a given nesting site, this species will nest in the same site as the colonial Northern Rough-winged Swallow.

The major factor influencing Belted Kingfisher selection of nesting habitat is proximity to a suitable water source. The species feeds primarily on small fish and typically forages in lakes, rivers, streams and the ocean (Appendix 4). Its foraging forays require that the nesting habitat be within easy flying distance (less than 1.5 km) of its food resource (Hamas 1975). Although water is not critical to the Northern Rough-winged Swallow, it is reported that burrows adjacent to rivers are predominant site selections in B.C.(Erskine 1979). Habitat components such as rivers (Appendix 4) provide the open terrain required by this aerial foraging insectivore. Both species require perches along the edge of or within their feeding habitat.

The stage of forest succession surrounding the nesting or feeding habitat does not limit habitat use for the species in this lifeform (Figure 2j, Appendix 5).

General Habitat Requirements

Reproduction

- nearly vertical bank of exposed soil, devoid of vegetation

Feeding

- water source (river, stream, lake, ocean)
- perches adjacent to water or open terrain

Special Habitat Requirements

Belted Kingfisher - suitable nesting embankment in the proximity of a clear, fish-inhabited water source

Northern Rough-winged Swallow - embankment nesting site adjacent to open foraging terrain

References: Hamas 1975, Erskine 1979.

9.13 Lifeform 11: REPRODUCES on small coastal islands or coastal shores on the ground, cliffs or in burrows.
FEEDS in or on water.

Fork-tailed Storm-Petrel, Pelagic Cormorant, Black Oystercatcher

Seabirds breeding along the coastal shores of Vancouver Island or on the offshore small coastal islands fall within this lifeform. Most are colonial nesters. These species can be divided into two categories according to their nest type: burrow-rock crevice or open nest. Burrowing species include storm-petrels (Fork-tailed, Leach's) and alcids (Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin). These species require a surface substrate suitable for excavation. In B.C. both treed and treeless islands are used (Appendix 4). On treed islands, nest sites at the forest edge with little or no understory predominate. Rhinoceros Auklet burrows have been reported in a range of

vegetation types from open areas dominated by salmonberry (Rubus spectabilus) (Hancock 1970) to mature Douglas-fir/western hemlock stands (Young 1930). Burrows are made in bare or moss- and grass-covered ground, and Vermeer et al. (1979) found on Triangle Island (B.C.) that a burrowing substrate composed of rock, less than 3 cm long and 44% of the substrate composition (33% soil, 23% vegetation), did not appear to limit nesting. These authors further suggest that slope influences the selection of suitable breeding habitat. They found that the Tufted Puffin preferred steep slopes or cliff tops free from tall vegetation, while the Rhinoceros Auklet nested on gradual slopes and flat areas; Cassin's Auklet nested only in flat areas. They suggest that the selection of different slopes is due to the effect of the inherent wing-loading on the initial flight pattern of each species. The Pigeon Guillemot nests in rock cavities, crevices, and similar sheltered sites.

Open nesting species include the Double-crested Cormorant, Brandt's Cormorant, Glaucous-winged Gull, Black Oystercatcher, Pelagic Cormorant and Common Murre. The first four species nest on flat or sloping coastal islands and shores, while the later two typically nest on a cliff face (Manuwal and Campbell 1979).

An important criterion is fulfilled with the inaccessibility of the nesting habitat of these seabirds. It allows freedom from or minimizes terrestrial predation. This freedom from predation is especially critical for burrowing species (storm-petrels and alcids). Their restricted breeding distribution on coastal islands emphasizes this dependence.

Species in this lifeform feed in a variety of marine situations from the intertidal zone to the open ocean (Appendix 4). For example, the Black Oystercatcher forages, exclusively, along the intertidal shore. Cormorants and Pigeon Guillemots feed in the littoral zone, alcids near shore, and storm-petrels well-offshore (i.e. pelagic). Although food supply and available nest sites are noted as the two critical factors influencing seabird distribution and abundance, fluctuating or declining food supply has not been reported as a factor currently limiting seabird populations.

The stage of forest succession has very little influence on the nesting habitat use by most of these species (Figure 2k, Appendix 5).

General Habitat Requirements

Reproduction

- minimal human disturbance
- suitable burrowing substrate and depth (storm-petrels and alcids)
- inaccessible shoreline ridges, cliffs, talus or rocky ground
- predator-free islands

Feeding

- marine environment (pollution-free)

References: Robertson 1974, Manuwal and Campbell 1979, Vermeer et al. 1979.

9.14 Summary Discussion

Information on species use of the habitat components and stages of forest succession are presented and form the information base used to 1) discuss the feeding and reproduction habitat requirements of each of the 11 lifeforms and their species, and 2) illustrate the role vegetation structure plays in species habitat selection and the resultant bird species community. The following text summarizes the findings of this analysis.

The intermediate stages of forest succession (i.e. shrub/seedling to mature) provide habitat for a large number of species (Figure 1). Though the total number of species remains relatively constant, the species community is continually changing. As forest succession advances, feeding habitat decreases while nesting habitat increases. For many species, use of the shrub/seedling and grass/forb stages as foraging habitat is dependent on the availability of perch trees and the proximity to nesting habitat. The young and mature stages provide nesting habitat for the majority of these species. Several species are able to satisfy both feeding and reproduction habitat requirements in the same successional stage.

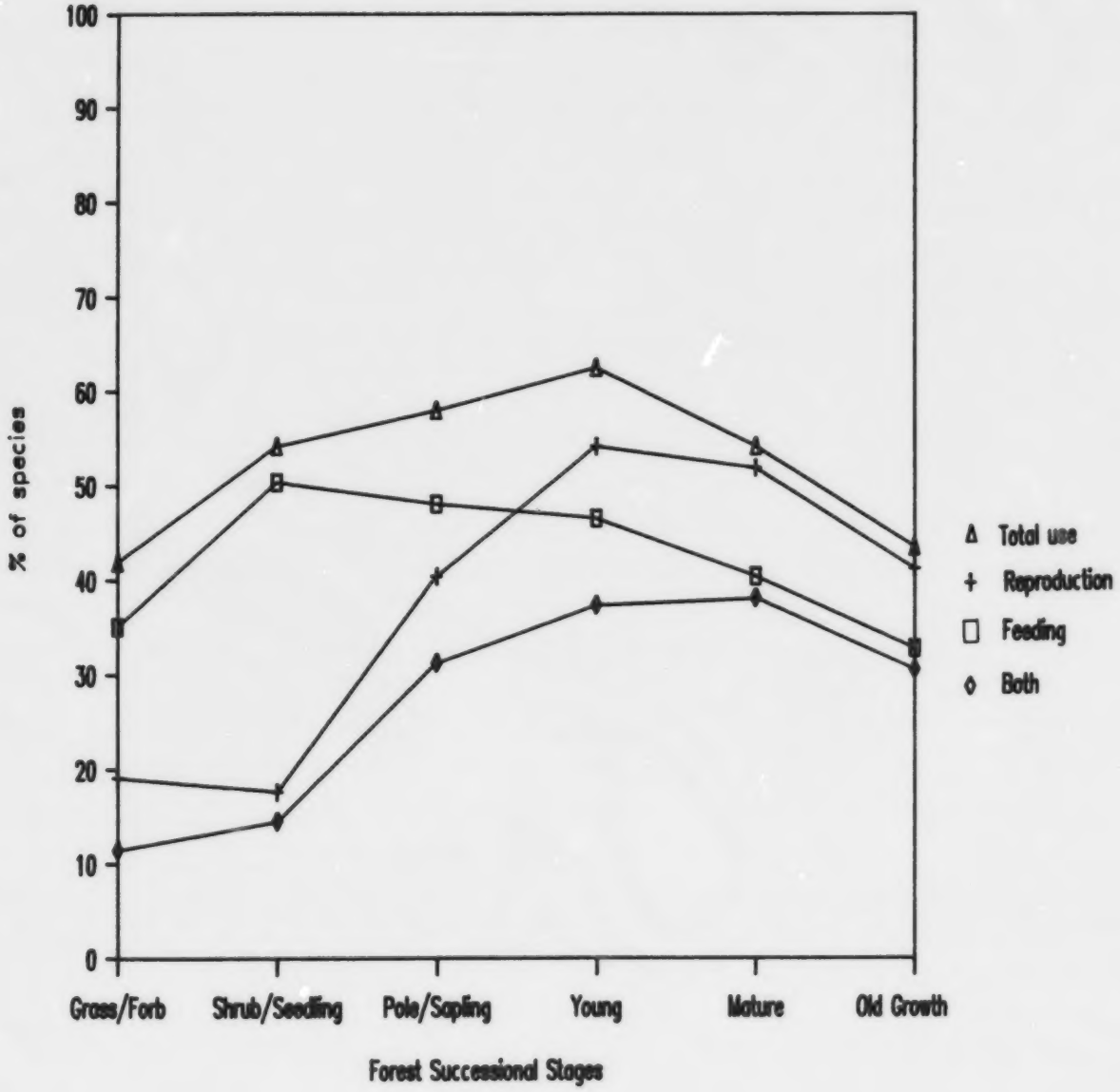

FIGURE 1. Orientation of all breeding birds species to forest successional stages.

The forest successional stage that provides feeding habitat for the most species in each lifeform is, as follows (Figure 2):

Grass/Forb	Lifeform 1 :	e.g. Common Loon, Bald Eagle, Spotted Sandpiper
	Lifeform 2 :	e.g. Peregrine Falcon
	Lifeform 3 :	e.g. Blue Grouse, Common Nighthawk, Savannah Sparrow
	Lifeform 10[1]:	e.g. Belted Kingfisher
Shrub/Seedling	Lifeform 4 :	e.g. Yellow Warbler, Fox Sparrow
	Lifeform 5[1]:	e.g. Warbling Vireo, Black-headed Grosbeak
	Lifeform 9 :	e.g. Western Screech-Owl, Tree Swallow, Chestnut-backed Chickadee
	Lifeform 10[1]:	e.g. Belted Kingfisher
Pole/Sapling	Lifeform 5[1]:	e.g. Warbling Vireo, Black-headed Grosbeak
	Lifeform 7 :	e.g. Cooper's Hawk, Northwestern Crow
	Lifeform 10[1]:	e.g. Belted Kingfisher
Young	Lifeform 5[1]:	e.g. Warbling Vireo, Black-headed Grosbeak
	Lifeform 10[1]:	e.g. Belted Kingfisher
Mature	Lifeform 5[1]:	e.g. Warbling Vireo, Black-headed Grosbeak
	Lifeform 6 :	e.g. Western Flycatcher, Steller's Jay, Townsend's Warbler
	Lifeform 8[1]:	e.g. Pileated Woodpecker, Downy Woodpecker
	Lifeform 10[1]:	e.g. Belted Kingfisher
Old growth	Lifeform 8[1]:	e.g. Pileated Woodpecker, Downy Woodpecker
	Lifeform 10[1]:	e.g. Belted Kingfisher

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1 Maximum number of species in more than one successional stage.

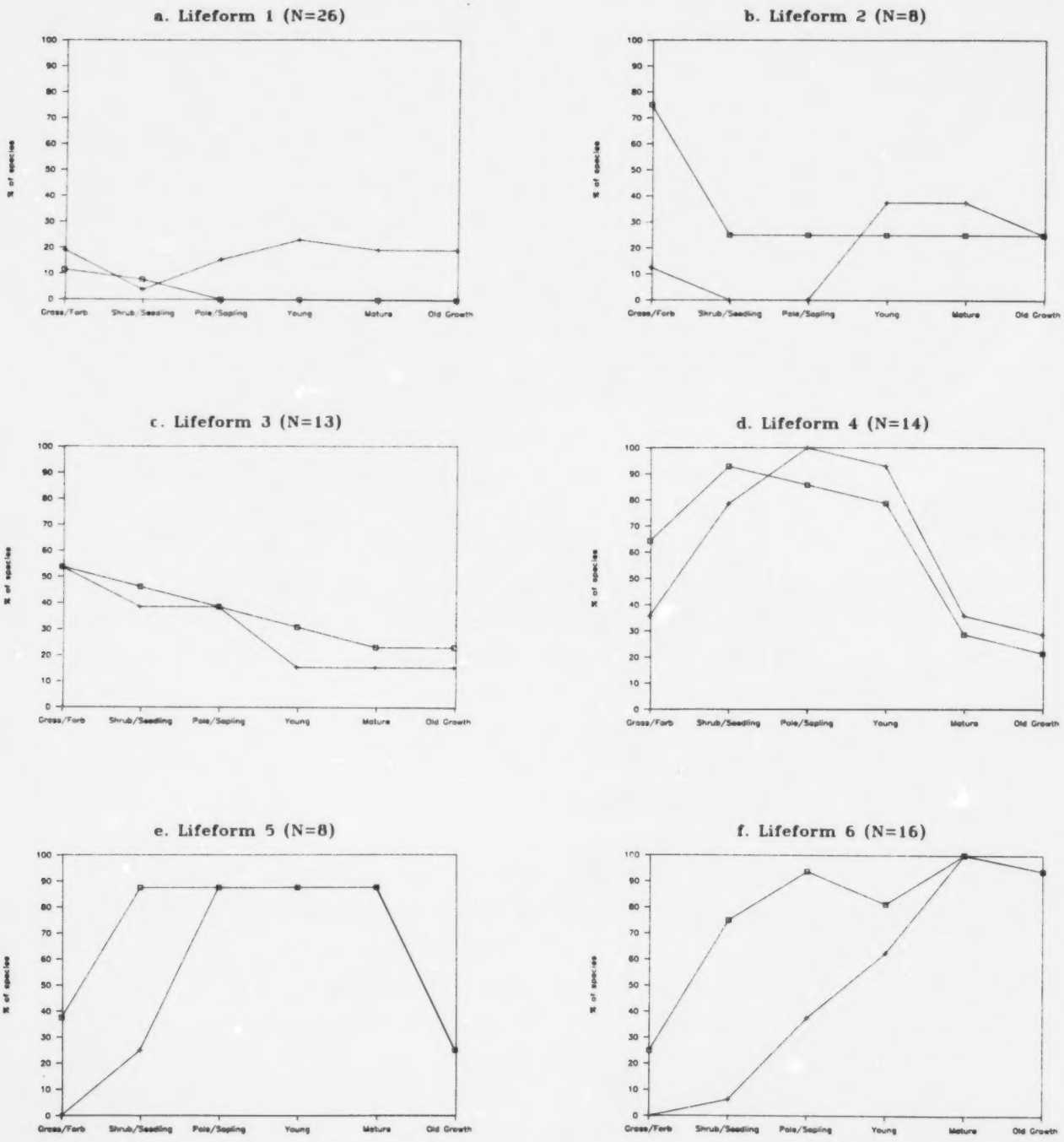
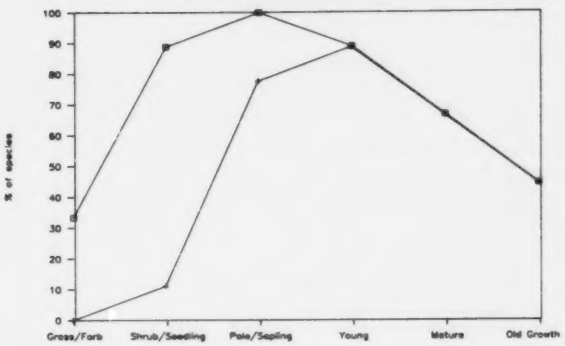
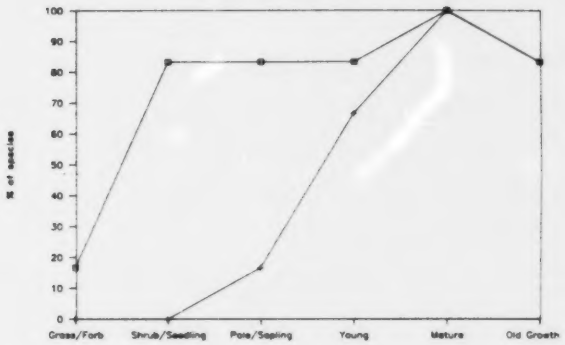


FIGURE 2. Orientation of lifeforms to forest successional stages for feeding (□) and reproduction (+).

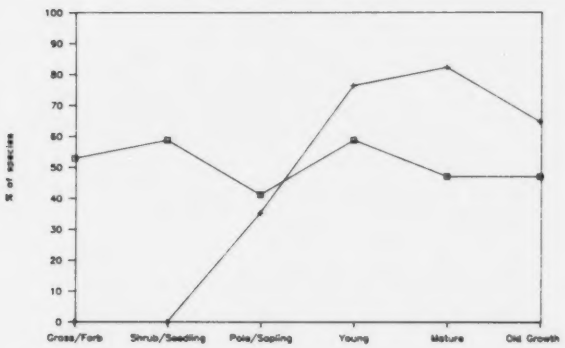
g. Lifeform 7 (N=9)



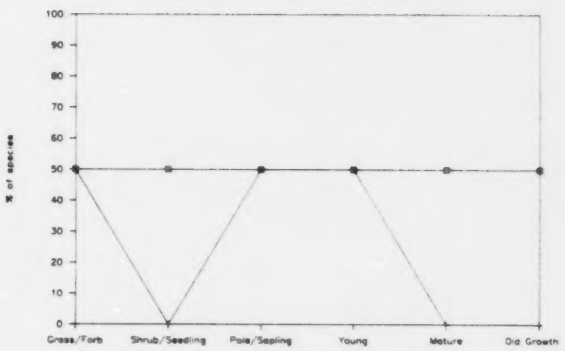
h. Lifeform 8 (N=6)



i. Lifeform 9 (N=17)



j. Lifeform 10 (N=2)



k. Lifeform 11 (N=12)

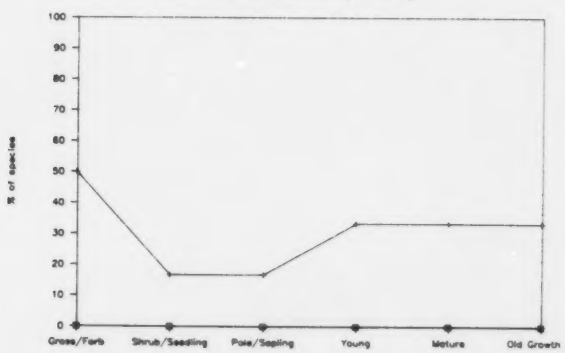


FIGURE 2. Orientation of lifeforms to forest successional stages for feeding (□) and reproduction (+). Continued.

Species in Lifeform 11 (e.g. Fork-tailed Storm Petrel, Pelagic Cormorant, Black Oystercatcher) are not associated with forest successional stages for feeding. Feeding requirements are the ultimate factors limiting populations of Peregrine Falcon, Red Crossbill and Three-toed Woodpecker. It is concluded that the lifeforms most closely associated with forest successional stages for feeding are lifeforms 4, 8, and 9.

The forest successional stage that provides nesting habitat for the most species in each lifeform is, as follows (Figure 2):

Grass/Forb	Lifeform 3	- ground nesting species
	Lifeform 11	- ground and burrow nesting seabirds
Shrub/Seedling	none	
Pole/Sapling	Lifeform 4	- shrub nesting species
	Lifeform 5[1]	- deciduous tree nesting species
Young	Lifeform 5[1]	- deciduous tree nesting species
	Lifeform 7	- deciduous or conifer tree nesting species
Mature	Lifeform 5[1]	- deciduous tree nesting species
	Lifeform 6	- conifer tree nesting species
	Lifeform 8[1]	- primary cavity nesting species
Old Growth	Lifeform 1	- large limb nesting species
	Lifeform 8[1]	- primary cavity nesting species

Lifeforms 1 (non tree nesting species), 2 (cliff nesting species), and 10 (bank-burrow nesting species) are not associated with forest successional stages for reproduction. It is concluded that species in Lifeforms 8, 1 (tree nesting species), 6, 4 and 9 are most closely associated with the stages of forest succession for their reproduction.

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1 Maximum number of species in more than one successional stage.

In summary, Figure 3 illustrates the pattern and composition of the breeding bird species community as forest succession advances and becomes more diverse. Using this information, predictions can be made on changes to the breeding bird species community with alterations to the vegetation structure.

10 EFFECTS OF INTENSIVE FOREST MANAGEMENT

10.1 Introduction

Over the past decade, interest in the relationship between intensive forest management and forest birds has increased substantially. The volume of theoretical material and documentation of the effects and long-term consequences of intensive forest management on the bird species community has also increased (e.g. Roe 1974, Smith 1975, Bunnell and Eastman 1976, DeGraaf 1978, McClelland et al. 1979, Thomas 1979, DeGraaf 1980). Many of these studies have occurred in coniferous forests, but few have been conducted on Vancouver Island or in similar west coast coniferous forests (e.g. Fry 1982, Davis et al. 1983, Emmett 1983).

10.2 Methods

This analysis is based, primarily, on the few field studies conducted on Vancouver Island, on the B.C. mainland in the same biogeoclimatic zones as those that occur on the Island, and in similar coniferous forests in the U.S. Pacific Northwest states (Washington and Oregon) and southeast Alaska. Studies occurring in coniferous forests elsewhere in the west (e.g. Arizona, California) provided additional background information on general principles and basic trends in species composition following habitat alteration. The discussion presented in the following text is based on results of this documentation; on the effects of intensive forest management on vegetation structure and pattern of development described in the literature (Edgerton and Thomas 1978, Thomas et al. 1979); and on the predicted effects of intensive forest management on habitat requirements and species habitat use (Section 9).

This analysis on the effects of intensive forest management on the breeding birds of Vancouver Island is limited to the lifeforms or the group of species within a lifeform that require forests or occur in stages of forest

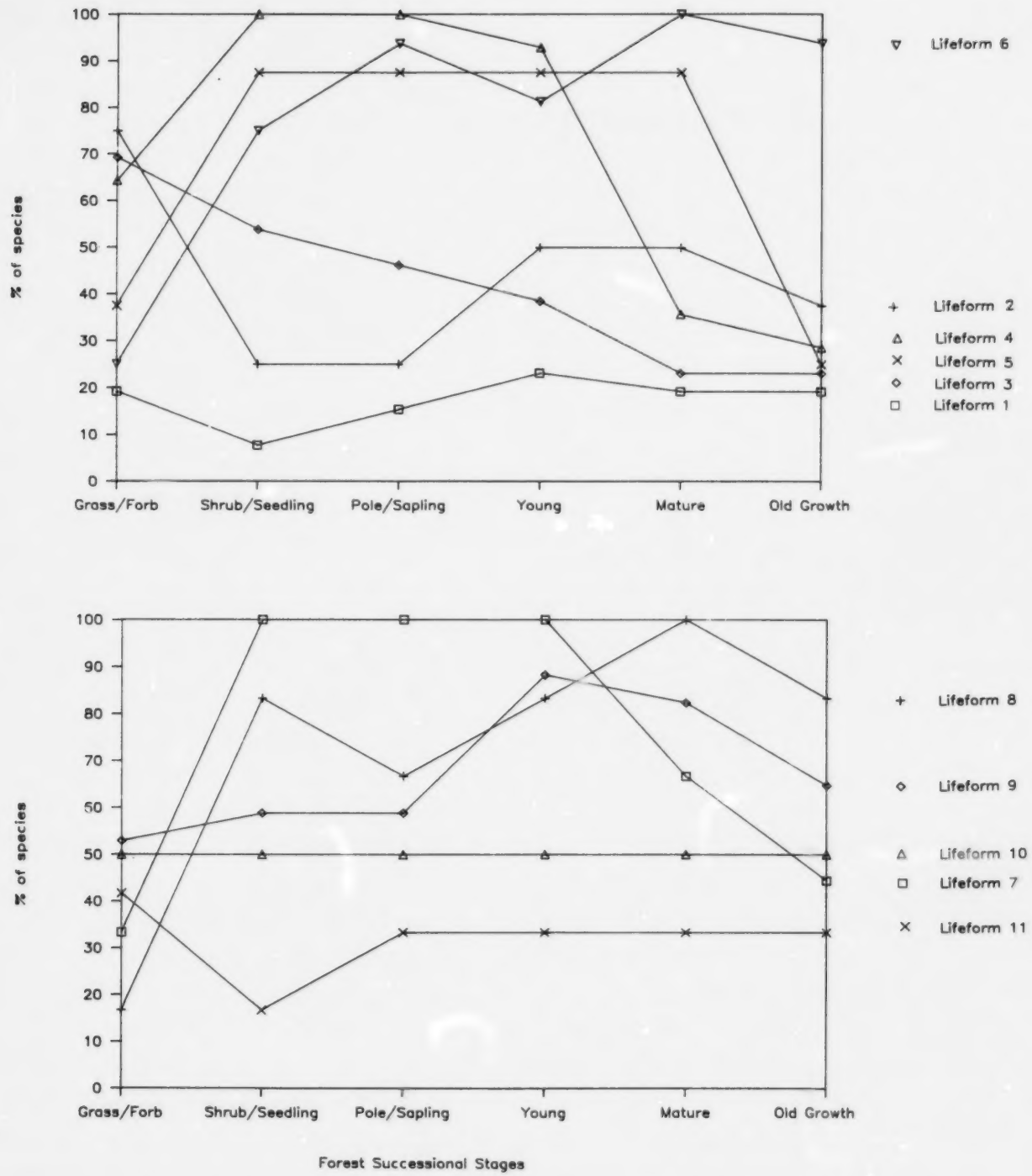

FIGURE 3. Percentage of lifeform species using forest successional stages for feeding and/or reproduction.

succession during forest development to climax. This approach was adopted because it was assumed that the impact of intensive forest management would be greatest on these groups of species. The analysis therefore includes only Lifeforms 3 through 9 and the tree nesting species in lifeform 1. Lifeforms 1 (non tree nesting species), 2, 10 and 11 were not included. The effects of forest practices on some of the species not included in this analysis (e.g. waterfowl) are documented elsewhere (Hunter and Jones 1982).

While intensive forest management involves a range of silviculture practices, this analysis focused only on those commonly in use on Vancouver Island. Clearcutting is virtually the only harvesting technique currently in use on the Island and thus the only one addressed. Site preparation, stand establishment, and stand tending techniques include, respectively: burning or no site preparation (i.e. logging slash remains); natural regeneration or (conifer) planting; and deciduous/conifer competition treatments, precommercial thinning, and commercial thinning. These forest practices were also selected because their widespread use now is likely to continue in the future. Also included, for each lifeform, is an overview of forest stand development in terms of the changes in the breeding bird species composition during post-harvested stand development (i.e. pre-conifer regeneration and conifer second growth) and the long-term consequences of intensive forest management.

The effects of these forest practices on the species within each lifeform, as well as on the lifeform acting as a functional niche, are discussed in the following text and summarized in Appendix 7.

10.3 Lifeform 1: REPRODUCES near or on water.
FEEDS on ground; in shrubs, trees or water.

Tree nesting species only - Great Blue Heron, Common Merganser, Bald Eagle, Osprey. These species require stands of similar age, tree size, and structure. Discussion is limited to the Bald Eagle and serves as an example for this group of species.

10.3.1 Clearcutting

The major effect of clearcutting on these species is the destruction of their nesting habitat. Shoreline clearcutting is reported to be the most detrimental (Corr 1974, Anthony et al. 1982). Clearcutting, in areas adjacent to nest sites, was found to also decrease nesting productivity (Grubb 1981), disrupt site use (Anthony and Isaacs 1981), and increase territorial antagonism (Mahaffy 1981). Noise from the logging activity and a decrease or elimination of the visual screening of the nest site (i.e. with vegetation) are the primary causes.

Clearcutting, however, need not be totally destructive. Recently, guidelines for the provision of nesting habitat during forest harvesting have been proposed (Anthony et al. 1982, Stalmaster et al. 1982) and are currently in use in some parts of the U.S. (Fraser 1981, U.S. Fish and Wildlife Service 1981). On Vancouver Island, shoreline logging operational procedures for the protection and management of Bald Eagle and Osprey habitat have been drafted (Morrison and Janz 1983). These however have not been implemented and are currently in use only as guidelines, for use at the discretion of the logging company.

Foraging habitat, although important, was viewed to be less affected by forestry-related activities than nesting, roosting and loafing sites (Stalmaster et al. 1982).

10.3.2 Site preparation

No site preparation

No information available. No treatment effect: post-harvested sites lack habitat components necessary for nesting and feeding (see "Clearcutting", above).

Burning

No information is available. No treatment effect; site unsuitable (see "No site preparation", above).

10.3.3 Stand establishment

Natural regeneration

No information is available; no short term effect is predicted.

Planting

No information is available; no short term effect is predicted.

10.3.4 Stand tending

Deciduous/conifer competition

No effect. Habitat unsuitable at this stage of succession.

Precommercial thinning

No effect; habitat unsuitable at this stage of forest development. Planning to provide future nesting habitat should begin. Potential nest sites and nesting habitat should be selected at this stage of tree development.

Commercial thinning

No effect. Trees have not developed the required nest tree structure at this stage of forest development; however, provision for future nesting habitats is possible and should be implemented at this time through retention of potential nest trees and their surrounding vegetation.

10.3.5 Stand development

Studies on species use of the pole/sapling and young forest successional stages are lacking.

Following clearcutting, trees do not develop the nest tree structure required until just prior to rotation (80 yr) and, at that time, their suitability as nest trees is still only marginal. Elimination of the later stages of forest succession (i.e. mature and old growth) (Figure 4a) would reduce and could potentially eliminate nesting habitat available. As a consequence, local populations would be eliminated and species distribution diminished. Stalmaster et al. (1982) proposed, however, that properly designed harvesting and silvicultural methods could create and maintain suitable Bald Eagle habitat.

10.4 Lifeform 3: REPRODUCES on ground without specific water, cliff, rimrock or talus association.
FEEDS on ground; in shrubs, tree, or air.

Blue Grouse, Common Nighthawk, Savannah Sparrow

10.4.1 Clearcutting

Clearcutting will benefit this lifeform. Increasing the availability of stands in the early stages of forest succession development (i.e. grass/forb to pole/sapling), increases the nesting and feeding habitat available to the majority of these species (Roe 1974, Fry 1982) (Section 9.5, Appendix 6). On Vancouver Island, Blue Grouse populations were reported to increase rapidly following clearcutting of their forested lowland nesting habitat (Redfield et al. 1970), suggesting a concomitant increase in habitat suitability with clearcutting. This result, however, is not conclusive, for in some areas populations remained the same after clearcutting (Bendell pers. comm.). Food quality has been studied as a possible cause for these conflicting responses (Redfield et al. 1970, Zwickel and Bendell 1972, Ash et al. 1977), but it has not been proven. Recently, a genetic-based behavourial response has been proposed as the factor responsible for flucuations in grouse populations (Page and Bergerud 1984). This hypothesis is based on a functional change in the genetic composition of the population and the resulting interactive responses of passive and aggressive individuals. In light of this, there is a need to clarify the role of this genetic-based response and the role of the habitat-based response to determine to what extent habitat changes due to clearcutting influence Blue Grouse population increases.

The Hermit Thrush appears to be quite sensitive to habitat alteration, and the literature suggests that clearcutting will adversely affect this forest dwelling species (Hagar 1960, Franzreb 1977, Fry 1982). Monthey (1983) found that in stands with only 25% tree removal, thrush densities were significantly lower than in forested stands.

Although the tree nesting behavior of the Marbled Murrelet has not been verified on Vancouver Island, information suggests that at-sea populations have decreased in areas adjacent to intensive logging activity (Sealy and Carter 1984).

10.4.2. Site preparation

No site preparation

This practice has little affect on this lifeform. Of the few studies that report species use of slash-covered clearcuts, the data indicated that species use was minimal (Hagar 1960, Roe 1974). On Vancouver Island, only Rufous-sided Towhee and Blue Grouse were reported in slash (Redfield et al. 1970, Fry 1982); species activity was not reported.

Burning

The limited information available indicates that while burning would have little effect on the majority of species in this lifeform, it does reduce the suitability of Blue Grouse habitat. Studies on Vancouver Island of the effects of burning on Blue Grouse population numbers found that migration from its lowland spring ranges (nesting) to its conifer upland winter range occurred earlier than usual on burned sites (Zwickel and Bendell 1967, Redfield et al. 1970). Surprisingly, shortage of water was suspected as the cause, since food -- although dry -- was abundant.

10.4.3 Stand establishment

Natural regeneration

Although information is limited, it is predicted that because of the various nesting habitat vegetation types used (Section 9.5), this practice is beneficial. Blue Grouse is the species commonly reported to occur in regenerating lowland clearcuts. Fry (1982) found that a 3-year old clearcut (CWH) was the only stand used by Wilson's Warbler.

Planting

The information available on the effects of planting is limited to the damage caused by Blue Grouse. The effect on Blue Grouse is positive: planting increases their food resource. This species feeds on the freshly planted conifer seedlings, clipping the tips and buds, and consequently destroys or stunts seedling growth (Howard 1982). It is suspected that seedlings would provide additional perch sites for some species.

10.4.4 Stand tending

Deciduous/conifer competition

No studies have occurred in B.C. The only study conducted in the U.S. Pacific Northwest (western Oregon) found that for Orange-crowned Warbler, Rufous-sided Towhee and Wilson's Warbler densities decreased (some significantly) following herbicide treatment to control deciduous tree (primarily red alder) cover (Morrison and Meslow 1984).

Pre-commercial thinning

Very little research has been conducted. Any increase in the shrub layer will benefit ground nesting species (e.g. Rufous-sided Towhee), which rely on this vegetation layer to provide nesting cover.

In Idaho, moderate-light thinning was insufficient to measurably increase growth of key shrub and ground-cover food plants for Ruffed Grouse (Marsh 1954).

Commercial thinning

No information is available. This practice should not affect the habitat suitability of species currently in residence; duration of habitat suitability should be lengthened for some.

10.4.5 Stand development

Studies on species composition in stands from pre-conifer to pole/sapling stages found that the majority of species in this lifeform occur throughout

stand development, from the low herb shrub stage to the dense shrub open canopy stage. For Vancouver Island, information on the species and stand age is limited and variable. For example, Roe (1974) found Wilson's Warbler exclusively in a 24-year-old unplanted stand, while Fry (1982) reported this species exclusively in a 3-year-old unplanted clearcut. Both studies occurred in CWH on the west side of Vancouver Island (Pacific Rim National Park and Carnation Creek respectively). It is suggested that the similar results are due to similarities in the moisture and vegetation density of the lower statum in these stands. In general, the bird species community changes from one of ground nesting species which use grass/forb habitat to shrub habitat nesting species (see Section 9.5 for species groupings).

Though the predicted shortening of early successional stages (i.e. grass/forb, shrub) would eliminate this lifeform's preferred habitat (Figure 4b), current forest management (i.e. in terms of number of hectares in early second growth, treatment of competing vegetation, harvesting schedules) lessens any immediate concern for these species. From the information gathered it appears that the Hermit Thrush will be negatively affected by the elimination of the mature and old-growth stages of forest succession; however, the degree to which this species will be affected is difficult to assess.

10.5 Lifeform 4: REPRODUCES in shrubs.
FEEDS on ground; in shrubs, trees, or air.

Yellow Warbler, Fox Sparrow

10.5.1 Clearcutting

Generally not found in mature forests, the species in this lifeform will benefit from clearcutting. Stands in various stages of early succession (grass/forb to pole/sapling) are used by many of these species. Clearcuts are initially invaded by the Dark-eyed Junco and this species thrives in the first years of stand development. Throughout the development of the shrub layer, all species find their preferred habitat at various times and for various durations (Hagar 1960, Horvath 1963, Roe 1974, Buckner et al. 1975, Fry 1982).

10.5.2 Site preparation

No site preparation

This practice is reported to maintain the cover and feeding habitat for some species in this lifeform. On Vancouver Island and elsewhere, the Dark-eyed Junco is typically associated with logging slash. Slash acts as a foraging substrate (insects), perch, escape and nest cover for this species and they are reported to be particularly dependent on slash as escape cover until shrubs invade (Hager 1960). Song Sparrows were also reported to use slash but to a lesser degree (Fry 1982).

Burning

Burning will have a negative affect on the few species reported to occur on slash-covered clearcuts. For example, Hagar (1960) suggests that slash burning be used as a means to control the Dark-eyed Junco, a seed eating species that hampers natural reforestation.

10.5.3 Stand establishment

Natural regeneration

Initial invasion of weedy vegetation provides food for seed-eating species such as the Dark-eyed Junco, American Goldfinch, and Song, Fox, and White-crowned Sparrows (Roe 1974, Fry 1982).

Planting

Morrison and Meslow (1983a) report that conifer seedlings (4-9 years post-planting) provided ample cover for species preferring low, shrubbery habitat (e.g. sparrows, Rufous Hummingbird, MacGillivray's Warbler). Seedlings will also provide additional perch sites.

10.5.4 Stand tending

Deciduous/conifer competition

No studies have been conducted in B.C. In western Oregon, Morrison and Meslow (1984) found that herbicide treatment to control deciduous cover (primarily red alder) had no permanent adverse effects on the majority of

these shrub nesting species. Most species compensated for loss of habitat following initial defoliation of shrubs by altering their foraging behaviour. One species unable to compensate adequately was MacGillivray's Warbler; however, as shrub foliage developed again this species recovered. A similar response by the Willow Flycatcher is suggested (Verner and Boss 1980).

Precommercial thinning

Studies are lacking. Any increase in shrub density and therefore cover should benefit resident species and increase habitat suitability for species preferring habitat with a dense shrub layer (e.g. Swainson's Thrush).

Commercial thinning

Information on the effects of thinning are lacking. An increase in the shrub layer following opening of the canopy will increase the availability of suitable habitat for many of the species occurring at this age of the stand (Appendix 5). Foraging maneuverability for aerial feeders will be improved. Stand suitability will be prolonged.

10.5.5 Stand development

Studies on Vancouver Island (Roe 1974, Buckner et al. 1975, Fry 1982) and from elsewhere in west coast coniferous forests (Hagar 1960, Horvath 1963, Monthey 1983, Morrison and Meslow 1983a and 1983b) report similar changes in species communities during regeneration of the forest stand. Initial invasion by Dark-eyed Junco and Song, Fox, and White-crowned Sparrows as ground cover and shrub layer begin to develop is overlapped by species such as the American Goldfinch and Willow Flycatcher. During this stage, habitat is used primarily for foraging by many of these species. As the shrubs increase in height and coverage, habitat suitability decreases for some species and increases for others, such as the warblers. Habitat with a dense shrub subcanopy and a developing upper canopy is home for species such as Swainson's Thrush. On the west side of Vancouver Island in CWH, Roe's (1974) data indicated that a stand characterized by a thick shrub and ground cover interspersed with slash or bare ground and a second layer of trees would support most of the species in this lifeform.

Streamlining the early stages of succession has the potential to substantially affect many of these species (Figure 4c) but under the current forest management regime (see Section 10.4.5) the impact is lessened. The impact of forest practices on these species will need to be re-evaluated in the future as forest management becomes more intensive.

10.6 Lifeform 5: REPRODUCES primarily in deciduous trees.
FEEDS in shrubs, trees or on the ground.

Warbling Vireo, Black-headed Grosbeak

10.6.1 Clearcutting

Clearcutting eliminates nesting habitat for most species and creates foraging habitat for some. Species benefiting most from clearcutting include Cedar Waxwing, Black-headed Grosbeak (both, fruit and seed eaters), and Red-tailed Hawk (raptor) (Hagar 1960, Roe 1974, Fry 1982). Use of this habitat by the Red-tailed Hawk is, however, dependant on the proximity of the clearcut to their nesting site.

10.6.2 Site preparation

No site preparation

Species use of slash clearcuts is not documented. These open areas should provide foraging habitat for the Red-tailed Hawk provided their small mammal prey are present and perch trees along the perimeter are available.

Burning

No information is available. With the elimination of ground debris, a reduction in prey species and numbers will correspondingly affect the foraging suitability of the site for the Red-tailed Hawk.

10.6.3 Stand establishment

Natural regeneration

Early development of seed and fruit producing vegetation provides food for Cedar Waxwing (Fry 1982) and Black-headed Grosbeak (Hagar 1960). This practice should also provide foraging habitat (i.e. suitable prey habitat) for Red-tailed Hawk, provided perch trees along the clearcut perimeter are available.

Planting

No information is available. Seedlings, by providing food and cover for small mammal prey species and thus increasing the prey population, enhance the foraging habitat for the Red-tailed Hawk. Proximity of the nest tree, however, is still the limiting factor.

10.6.4 Stand tending

Deciduous/conifer competition

Mourning Dove numbers were reported to decline following spraying to control competing shrubs (Beaver 1976, Savidge 1977). A similar impact on Hutton's Vireo and Black-headed Grosbeak is suspected (Morgan pers. comm.).

Suppression of deciduous tree development as described by Morrison and Meslow (1984) will prolong the suitability of the foraging habitat for open area foraging species (e.g. Red-tailed Hawk), but retard or eliminate the development of suitable nesting sites for all species.

Precommercial thinning

Information is lacking. Since most species prefer open habitat with moderate canopy cover, prolonging a habitat structure similar to the early pole/sapling stage of forest succession would benefit many of these species. However, the consequences of eliminating the deciduous component in the stand will have a negative short- and long-term effect on these species.

Commercial thinning

No information is available. Species in this lifeform will benefit or have no effect from this alteration of habitat.

10.6.5 Stand development

Since most post-harvesting studies on breeding birds are conducted in the grass/forb to pole/sapling stages of forest succession, the information available on these species is limited. Species foraging in the grass/forb and pole/sapling stages are well reviewed in the literature (e.g. Red-tailed Hawk), but species nesting activity in the pole/sapling or young stage generally are not reported (Hagar 1960, Fry 1982). Information available consists primarily of lists that subjectively record species use in the various stages of forest succession (Wight 1974, Meslow 1978).

The information compiled in this analysis (Section 9.7, Appendix 5) indicates that an intensive forest management regime will continue to provide suitable habitat for the majority of these deciduous tree nesting species (Figure 4d). It is suggested however that this is likely to be the case only under the current regime. As stand tending practices become more intensive on Vancouver Island, the deciduous tree component will likely be significantly reduced or eliminated. It is hypothesized that the degree of reduction of this habitat component will directly reflect the degree of the negative impact on these deciduous tree nesting species. Although, as a group, these species are currently not threatened, there is a need to reassess their status in the future.

10.7 Lifeform 6: REPRODUCES primarily in conifers.
FEEDS in shrubs, tree or in the air.

Western Flycatcher, Steller's Jay, Townsend's Warbler

10.7.1 Clearcutting

Studies on Vancouver Island (Roe 1974, Fry 1982) and elsewhere (Morrison and Meslow 1983b, Raphael and Barrett 1983, Reynolds 1983) report that

clearcutting eliminated the habitat of species found in this lifeform. Species use of the forest opening created by clearcutting is minimal. Steller's Jay, the most adaptable species in this lifeform, was the only one commonly observed foraging in early clearcuts (Roe 1974, Scoullar 1980, Fry 1982). The occurrence of aerial foraging insectivores and raptors over regenerating clearcuts was minimal and depended on the availability of perch trees around the clearcut perimeter (e.g. Northern Goshawk, Great Horned Owl and flycatchers).

10.7.2 Site preparation

No site preparation

Little documentation of species habitat use is available. It is predicted that this practice will have little effect on species in this lifeform. The Steller's Jay is the only species reported to forage amongst the slash, foraging activity ranged from minimal (Hagar 1960, Roe 1974) to frequent (Scoullar 1980).

Burning

This practice has no effect on this lifeform. Reducing logging slash will only affect the marginal foraging habitat of the Steller's Jay.

10.7.3 Stand establishment

Natural regeneration

This practice has no effect on this lifeform. Documentation is limited. The Steller's Jay is the only species recorded in this habitat (Roe 1974).

Planting

Planting has no effect on this lifeform. Documentation is limited. Habitat suitability should remain unchanged for Steller's Jay.

10.7.4 Stand tending

Deciduous/conifer competition

No studies are available. Controlling deciduous growth may benefit the Steller's Jay. This practice will probably have very little or no effect on the other species since the habitat is virtually unused prior to treatment.

Precommercial thinning

Reynolds (1983) reported that thinning by decreasing stand density and deepening the crown would ultimately eliminate the potential of a stand to provide suitable Northern Goshawk nesting sites. It is therefore important that if Northern Goshawk nesting habitat is to be provided, planning must begin at this time.

The effects on most species in this lifeform are minimal. Only a few species, such as the Yellow-rumped Warbler and Ruby-crowned Kinglet were reported to occur in the transitional stage of development between the shrub/seedling and pole/sapling stages (Petersen and Petersen 1983).

Commercial thinning

Species response to commercial thinning is not well documented. Some species, particularly foliage nesters and foraging pickers and gleaners (e.g. warblers), were found to decrease in numbers following light to moderate-light clearcutting (Monthey 1983). A similar response is suspected to follow thinning. Reynolds (1983) recommended that tree harvesting within Northern Goshawk replacement stands be avoided because stands with closed or nearly closed canopies of mature trees are required to provide suitable nest sites.

10.7.5 Stand development

Although there is little information available on these species, there are two important conclusions. First, tree removal eliminates nesting habitat for all species in this lifeform, and second, the pole/sapling and young stages are used only nominally and by very few species.

The earliest reported inhabitant is the Steller's Jay and Scoullar (1980) reported that foraging habitat was provided in CWH stands 1-15 years old. Foraging use by other species (such as, Yellow-rumped Warbler, Olive-sided Flycatcher, Pine Siskin, Purple Finch) have also been reported, but was dependent on the availability of perch trees and adjacent mature nesting habitat (Morrison and Meslow 1983a). For example, the Olive-sided Flycatcher, found foraging in stands 1-35 years old, required adjacent stands over 75 years old, to provide suitable perching sites (Scoullar 1980).

The literature also indicated that the pole/sapling and young stages provided nesting habitat for very few species and, for most, habitat suitability was only marginal. Stands 16-35 years old (CWH) provide suitable nest trees for Steller's Jay (Scoullar 1980). Golden-crowned Kinglets were restricted to the densest patches of the forest canopy in 40-year-old CDF stands (Edwards and Stirling 1962). The only other species reported nesting in regenerating stands less than 80 years old were Townsend's Warbler (Edwards and Stirling 1962), Ruby-crowned Kinglet (Buckner et al. 1975, Petersen and Petersen 1983), Western Flycatcher (Edwards et al. 1962, Buckner et al. 1975) and Yellow-rumped Warbler (Petersen and Petersen 1983). All occurred in low densities.

The limited species use of the pole/sapling and young stages of forest succession and the apparent species dependence on mature stands suggests that intensive forest management, with its shortened commercial harvest rotation, will reduce number of species (Figure 4e) and species distribution.

10.8 Lifeform 7: REPRODUCES in conifers or deciduous trees.
FEEDS on ground; in shrubs or trees.

Cooper's Hawk, Northwestern Crow

10.8.1 Clearcutting

Studies on Vancouver Island indicate that first rotation clearcutting has little effect on this lifeform. Few species were recorded in these old growth stands and, when present, were at low densities (Band-tailed Pigeon, Varied Thrush, and Western Wood Pewee) (Roe 1974, Scoullar 1980, Fry 1982).

Open area foraging species, such as the Merlin and Cooper's Hawk, will benefit from this practice if the clearcut is within proximity to their nesting habitat.

10.8.2 Site preparation

No site preparation

This practice will have no effect on these species.

Burning

This practice will have no effect on these species.

10.8.3 Stand establishment

Natural regeneration

This practice has virtually no effect on this lifeform. Habitat use is minimal. Roe (1974) observed small numbers of Band-tailed Pigeon in 2-year old unplanted CWH stands; species activity was not reported.

Planting

Planting has no effect and there are no reports of species use of seedling plantations.

10.8.4 Stand tending

Deciduous/conifer competition

Herbicide treatment to control competing deciduous cover (primarily red alder) had no effect on the species reported to forage (Band-tailed Pigeon, Western Wood Pewee, Cooper's Hawk), perch (Evening Grosbeak, Varied Thrush), and nest (American Robin) in shrub/seedling and young pole/sapling stands (approximately 10-25 years) (Morrison and Meslow 1983a and 1984).

Precommercial thinning

Reynolds (1980) reported that precommercial thinning would decrease nesting habitat for Cooper's Hawk, and recommended that this practice be avoided in active and prospective nesting habitat. Information on the other species in this lifeform is lacking.

Commercial thinning

Commercial thinning was also reported to decrease suitability of Cooper's Hawk nesting habitat and Reynolds (1983) recommended that this practice be avoided if Cooper's Hawk nesting habitat was to be maintained. The effects of thinning are unreported for other species in this lifeform.

10.8.5 Stand development

Most post-harvesting studies focus on changes in species composition during forest development from clearcut to the young pole/sapling stages (less than 25 years). Of these studies, few mention species in this lifeform and, consequently, there has been little information documented on the pattern of species occurrence in managed conifer stands. These studies indicate that species occurrence in stands in the pre-conifer to young pole/sapling stages is minimal and dependent upon adjacent older stands to provide nesting habitat and forest edge perching sites for foraging (Scoullar 1980, Reynolds 1983, Morrison and Meslow 1983a). The species first reported in clearcuts were the American Robin and Band-tailed Pigeon. On Vancouver Island, Roe (1974) noted that their numbers increased with age of stand. Buckner et al. (1975) found Varied Thrush in similar densities in 20-year-old CWH stands as in old growth stands, while dense mature stands (tree height approximately 9 m) supported the highest density. In Oregon, Reynolds (1983) reports that even-aged conifer stands 30-70 years old (mean stand density of 907 stems/ha) provided the high canopy closure and tree density preferred by Cooper's Hawk.

The overall effect of intensive forest management (primarily by truncation), with its emphasis on the pole and young stages, should not have a major impact on most species in this lifeform (Figure 4f). The Western Tanager, Varied Thrush and Evening Grosbeak, because they require the stand structure and habitat components found in mature and old-growth stands, are the exceptions (Appendix 5).

10.9: Lifeform 8: REPRODUCES in excavated cavity in tree.
FEEDS on ground or in trees.

Pileated Woodpecker, Downy Woodpecker

10.9.1 Clearcutting

The elimination of primary cavity nesting species with the clearcutting of forested stands is well documented (Beebe, S.B. 1974, McClelland 1977, Scott et al. 1980, Raphael and White 1984). Snag removal during clearcutting eliminates woodpecker nesting and foraging sites. The Northern Flicker, is the one exception and clearcutting creates the open feeding habitat required by this ground foraging species (Scoullar 1980).

The length of time required to produce suitable snags (Cline et al. 1980) and the proposed rotation age of managed forests (Bunnell and Allaye-Chan 1984) has generated considerable concern (Bunnell and Eastman 1976, Pojar 1983). Maintaining the continued existence of these species may not be possible using the current harvesting method, clearcutting. As a result, modified clearcutting methods have been investigated to determine if suitable habitat could be provided. Morrison et al. (1983) investigated the possibility of high-cut stumping as an acceptable alternative to snags. This method is attractive because high-cut stumps (less than 2 m tall) are less hazardous to loggers than taller snags and present little revenue loss to the company. The author's review of the available literature, however, revealed that very few species would readily use such stumps. A study incorporating high-cut stumping has been set up by Morrison et al. and the data it provides may support their preliminary guidelines.

The use of snags retained during clearcutting has also been investigated. Many species were found to forage on these snags, but their use as foraging sites was dependent upon their proximity to nesting habitat (Mannan et al. 1980, Manuwal and Zarnowitz 1981, Marcot 1983, Morrison and Meslow 1983a). Species preferring open stands rather than dense timber frequented these clearcuts most often. The Hairy Woodpecker occurred significantly more

often in clearcuts with snags than in those without (Marcot 1983). The Northern Flicker was the species most often reported on these sites (Scott 1979, Mannan et al. 1980) and the only species reported nesting in a clearcut snag (Mannan et al. 1980). Although this method provides moderately suitable foraging habitat, these snags have not retained their suitability as nest trees.

10.9.2 Site preparation

No site preparation

Slash-covered clearcuts are used by few species. Mannan et al. (1980) frequently observed Northern Flicker, Pileated, Downy and Hairy woodpeckers foraging for insects on stumps and slash in clearcuts. Use of logging slash, however, was expected to only occur for the first rotation after clearcutting or after very advanced regeneration (Scoullar 1980). Although this comment was expressed for the Hairy Woodpecker, it is suggested that a similar effect is likely for all woodpeckers.

Burning

No information is available. Burning will eliminate the marginal foraging habitat created for a few species (see "No site preparation", above).

10.9.3 Stand establishment

Natural regeneration

Little information is available. Only the Northern Flicker was found to be typically associated with open, early regenerating sites (Roe 1974, Scoullar 1980).

Planting

No information is available on species occurrence in early seedling plantations. Once again, the Northern Flicker is the species most likely to use this habitat for foraging — at least until the conifer cover development reaches the pole stage (Scoullar 1980).

10.9.4 Stand tending

Deciduous/conifer competition

No studies report the occurrence of these species prior to or post-treatment. Treatments that increase ground foraging habitat would benefit the Northern Flicker; those that increase ground debris would reduce the suitability of their habitat. Because the Red-breasted Sapsucker is dependent on deciduous trees as a foraging substrate, any decrease in the availability of this stand component will have a negative impact on this species.

Precommercial thinning

No field studies reporting the effects of precommercial thinning on these species are reported in the literature. Eliminating cull trees would reduce or eliminate any provision for future snag trees (Bunnell and Allaye-Chan 1984). Decreasing stand density would favour the Northern Flicker and Hairy Woodpecker. The effect on the Northern Flicker's foraging habitat would depend on the degree of ground debris produced.

Commercial thinning

At this stage, some snags are sufficiently decayed to provide foraging sites, but are of insufficient size to provide suitable nest trees (Bunnell and Allaye-Chan 1984, Cline et al. 1980, Scoullar 1980). After thinning, few snags remain and the natural recruitment is disrupted (Cline et al. 1980). Consequently, the ability of the stand to provide foraging and nesting sites is reduced or eliminated (Bunnell and Allaye-Chan 1984). Since some species prefer foraging and nesting in snag clumps (e.g. Pileated Woodpecker, Three-toed Woodpecker) (Thomas 1979), decreasing the snag density and increasing distance between snags will adversely affect their foraging and nesting behaviour.

10.9.5 Stand development

In general the concern voiced following evaluation of all post-harvesting and forest regeneration studies is the inability of managed stands to provide trees and snags of sufficient size to satisfy the needs of primary cavity

nesters. Snag dimensions at rotation (projected dbh, 46 cm) (Bunnell and Allaye-Chan 1984) are not of sufficient diameter for cavity excavation of a suitable size. At this stage of stand development, trees and snags of suitable dimension and deterioration are just beginning to develop (Mannan et al. 1980, Cline et al 1980). Bunnell and Allaye-Chan (1984) in western hemlock and Mannan et al. (1980) in Douglas-fir stands (western Oregon) found no active nesting snags in stands less than 75 years old. Mannan et al. (1980) found that in Douglas-fir forests (western Oregon) snag use by hole-nesting species was concentrated in stands greater than 110 years old.

Managed forests prior to rotation harvest (proposed age, 70 yr) (Bunnell and Allaye-Chan 1984) are used primarily for foraging. Concomitantly with the increasing age of the forest stand, species numbers and foraging activity increases (Roe 1974, Scoullar 1980, Mannan et al. 1980). One exception, the Northern Flicker, concentrates its foraging activity in the youngest stands (15 yr), with activity decreasing as the canopy layer develops (Scoullar 1980). Mannan et al. (1980) found the highest densities of snags showing signs of foraging activity were in 75-year-old stands.

Clearly, the concern for the ability of intensive forest management practices to provide suitable habitat sites for these species is well founded. Elimination of the later stages of succession, loss of snags, inability of managed stands to provide suitable snags, and, to a lesser extent, shortening early succession (i.e. the grass/forb and shrub/seedling stages) will decrease cavity nesting species diversity and eventually eliminate a number of the primary cavity nesters (Figure 4g). While guidelines and strategies for maintaining and creating suitable snags throughout conifer stand development are numerous (e.g. Conner 1978, Bull et al. 1980, Cline et al. 1980, Davis et al. 1983, Raphael and White 1984), studies to evaluate their success have not been conducted.

10.10 Lifeform 9: REPRODUCES in cavity excavated by another or natural cavity.
FEEDS on ground, in water, or the air.

Western Screech-Owl, Tree Swallow, Chestnut-backed Chickadee

10.10.1 Clearcutting

Secondary cavity nesters are also adversely affected by clearcutting. The majority of species are dependent on primary cavity nesters (Lifeform 8, Section 10.9) for excavation of their nest sites, and are therefore correspondingly affected by their elimination (Section 10.9). Under the current forest management regime and its shortened rotation, natural cavity development is also hindered and consequently these nest sites are also unavailable. This is particularly critical to the Brown Creeper, for the natural aging process is essential to its nest site development (i.e. loose bark). Wrens have been reported nesting on clearcuts (Hagar 1960, Horvath 1963, Miller and Miller 1980), which suggests that post-logging debris provides characteristics similar to older stands for these species. Swallows have also been observed using residual or seed tree cavities (Morgan pers. comm.)

With clearcutting, the foraging sites of foliage gleaning species (e.g. Chestnut-backed Chickadee, Red-breasted Nuthatch) are eliminated, while available habitat for species foraging in forest openings is increased (e.g. American Kestrel, Violet-green Swallow). However, the latter species are dependent on the availability of perch sites (primarily snags) along the clearcut perimeter. Similar effects where shown for open foraging species when snags were retained within the clearcut (Balda 1975, McClelland 1977, Scott and Oldemeyer 1983). None of Vancouver Island's secondary cavity nesters were reported to use high-cut stumps (Morrison et al. 1983).

10.10.2 Site preparation

No site preparation

Slash piles have reportedly provided good foraging areas and nesting sites for House, Winter and Bewick's Wrens (Miller and Miller 1980).

Burning

Burning will destroy the habitat for the few species able to use slash (See "No site preparation" above).

10.10.3 Stand establishment

Natural regeneration

The literature suggests that this practice creates habitat that is used only minimally. On Vancouver Island Roe (1974) observed very low densities of Winter Wren in 2-year-old stands in CWH. As a forest opening, regenerating clearcuts provide foraging habitat for aerial feeding insectivorous species (e.g. Vaux's Swift, swallows) and raptors (owls). Foraging activity is modified by the availability of prey and perch sites.

Planting

Species use of seedling plantations is not reported and no effect is predicted. Species use of the plantation, as a forest opening, is expected to be similar to that described above (see "Natural Regeneration").

In contrast, Kessler's study (1979) in southeastern Alaska reported that Winter Wren abundance peaked in western hemlock - sitka spruce regeneration less than 5 years old.

10.10.4 Stand Tending

Deciduous/conifer competition

Of the few studies available, no secondary cavity nesters were reported to occur at this stage of stand development.

Precommercial thinning

No information is available. At this stage, vegetation is not suitable for nesting and provides only marginally suitable foraging habitat for a few species. Also see Section 10.9.4 "Precommercial thinning".

Commercial thinning

Information on treatment responses specific to secondary cavity nesters is not available. Treatment effects corresponding to those discussed for primary cavity nesters should also apply to these species (see Section 10.9.4 "Commercial thinning"). Species preferring stands of intermediate canopy coverage (e.g. Northern Saw-whet Owl) may benefit from this treatment.

10.10.5 Stand development

The concerns documented for primary cavity nesters in regenerating managed forests also apply to this lifeform of secondary cavity nesters (see Section 10.9.5).

Although a few species are found to nest in early stands, snags are the primary source of nest sites. The development of snags into suitable nest sites for this lifeform corresponds to that of primary excavators. Two species -- the Chestnut-backed Chickadee and Red-breasted Nuthatch -- can also excavate their own cavities. However, snags must be in advanced stages of deterioration and, consequently, these species -- especially the latter -- are typically found in the oldest stands.

The relationship between foraging habitat and stand development for this lifeform is different than that described for Lifeform 8 (Section 10.9). Clearcuts are used by aerial feeding insectivores and raptors, providing these clearcuts are adjacent to older stands (i.e. mature and old growth). Foliage and bark gleaners require stands in more advanced stages of forest stand development. For example, Scoullar (1980) reported that stands 36-75 years old (CWH) were just beginning to become suitable for the Chestnut-backed Chickadee, but he did not observe the Red-breasted Nuthatch until stands reached 76 years old and then they were only in the well-developed forest canopy.

Since the continued existence of the species in this lifeform depends on primary cavity nesters, intensive management practices that effect primary cavity nesters (Lifeform 8 - Section 10.9) will consequently also effect this lifeform. Of course, shortening of the rotation cycle and the concomitant elimination of natural cavity development will compound the scarcity of available nest sites for secondary, as well as primary, cavity nesting species (Figure 4h).

10.11 Summary Discussion

This analysis identified the effects of intensive forest management on breeding bird species of Vancouver Island and assessed the current status of the information available.

A review of the literature revealed that: (1) species information for Vancouver Island is minimal or entirely lacking for the majority of these breeding birds; (2) most field studies focus on species presence or absence before and after clearcutting, and document the bird species community from the grass/forb to pole/sapling stage of forest succession; and (3) data on species use of managed conifer stands in the mid-successional pole/sapling and young stages are lacking. This latter point identifies the major information gap in the literature.

In this analysis, it was found that clearcutting, with the concomitant reduction in available mature and old growth habitat and eventual elimination of these forest successional stages, would most adversely affect primary cavity nesting, large limb nesting, conifer tree nesting, and secondary cavity nesting species (lifeforms 8, 1, 6 and 9, respectively) (Figure 4). Forest management practices which advance forest succession by shortening the duration of the grass/forb and shrub/seedling stages were found to have the greatest impact on ground and shrub nesting species (lifeforms 3 and 4, respectively) (Figure 4). Breeding habitat of primary cavity, large limb, and conifer tree nesting species (lifeforms 8, 1 and 6, respectively) is affected the most as a result of intensive forest management; the feeding habitat of ground nesting and shrub nesting species (lifeforms 3 and 4, respectively) is affected the most. In general, shortening the duration of the pre-conifer

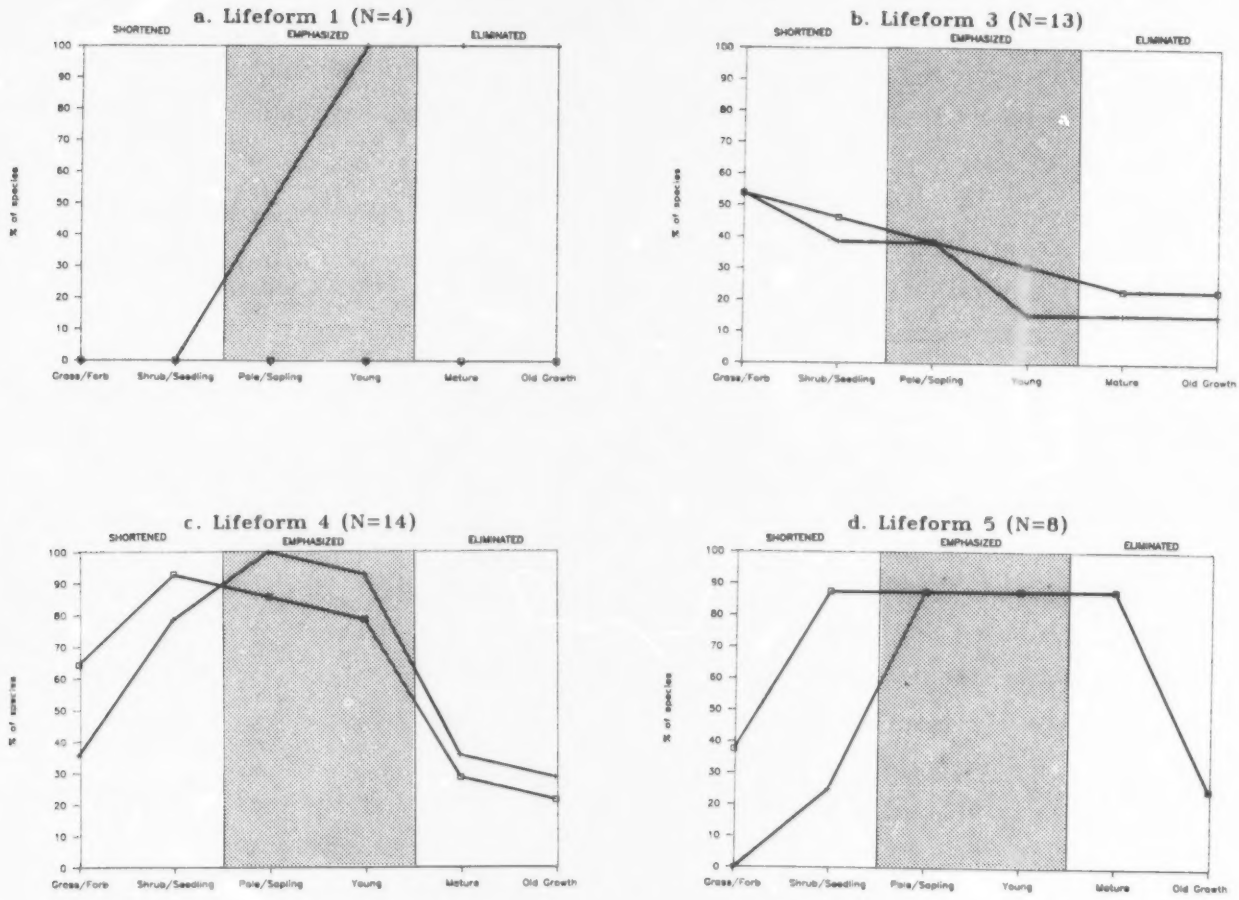

FIGURE 4. Orientation of selected lifeforms to forest successional stages for feeding (▫) and reproduction (+) and potential effects of intensive forest management on these stages.

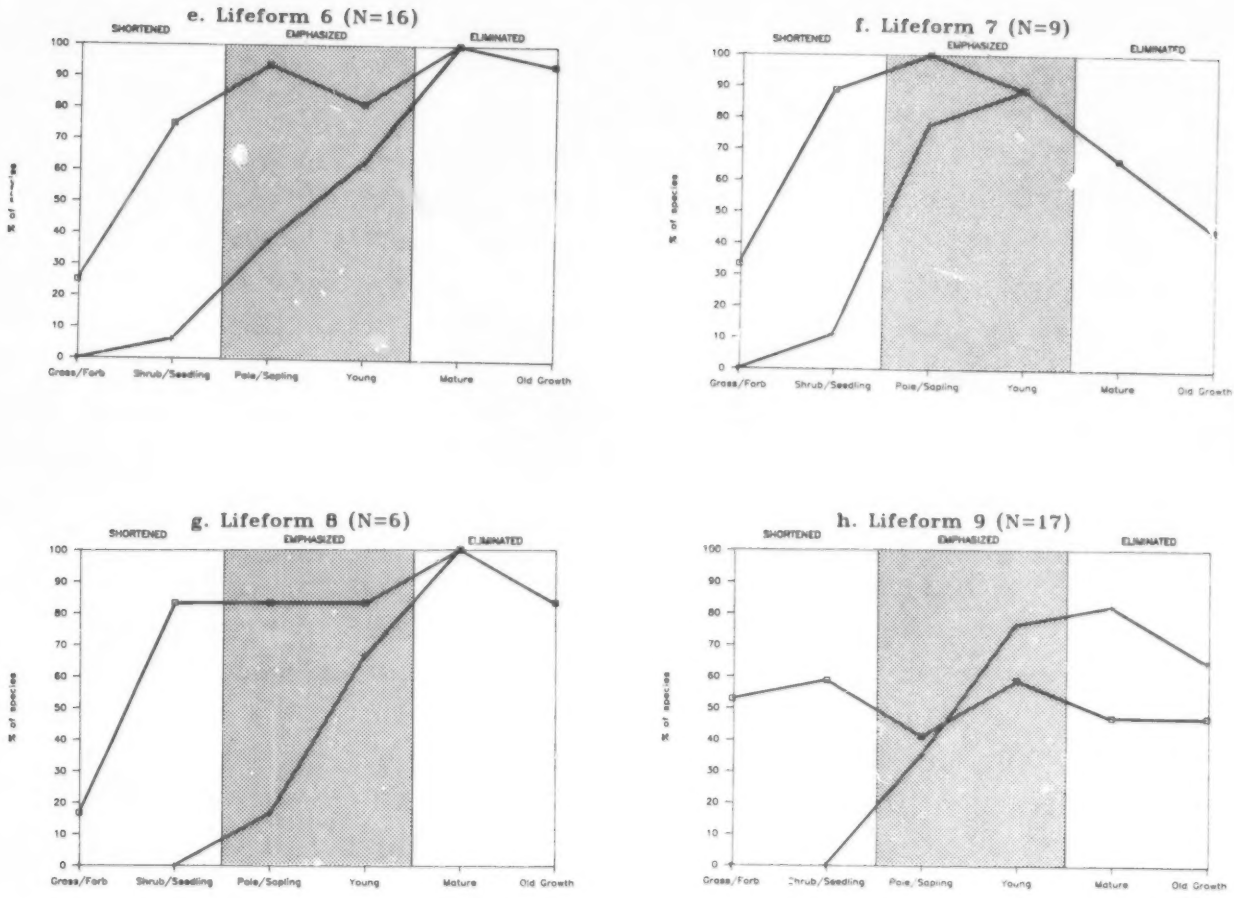

FIGURE 4. Orientation of selected lifeforms to forest successional stages for feeding (□) and reproduction (+) and potential effects of intensive forest management on these stages. Cont'd.

stages (i.e. grass/forb and shrub/seedling) affects the feeding habitat of these bird species; retarding succession affects their breeding habitat (Figure 5). While many species feed and reproduce in the same habitat, the habitat components necessary for reproduction are generally the limiting factors and therefore the effects of intensive forest management on breeding habitat are the most critical.

On Vancouver Island, first rotation clearcutting has the greatest impact on the Island's breeding bird species. Stand tending techniques, under the current forest management regime, have, at present, little impact on these species. The species that face the greatest threat from forest management practices are those that require the habitat components and stand structure of the mature and old growth forest (Table 8).

For many of these species, snags are the ultimate factor limiting population levels. In British Columbia, snags (standing dead trees) and live culls (dying and deformed trees), together, are defined as wildlife trees. Recently, a problem analysis on wildlife tree management in B.C. has been completed (Miller 1985). Currently, maintaining and creating wildlife trees is met with considerable opposition. As well, the current forest management regime used in B.C.'s coastal forests does not readily accommodate the provision for wildlife trees. In the U.S.A., in contrast, there is an established and growing acceptance of their value to wildlife. In light of this and the fact that wildlife trees are used for feeding and reproduction by many (36%) of Vancouver Island's breeding bird species, it is timely to invest in wildlife tree research and management.

It is concluded that the potential for intensive forest management to alter the breeding bird community on Vancouver Island is significant. Theoretically, by truncating forest succession -- the earliest stages shortened, the later stages eliminated -- the resultant breeding bird community will be dramatically simplified; some species will be eliminated. Clearly, to maintain breeding bird species diversity and species distrubution while manipulating the forest land base on which they live is the major timber-bird management challenge and a most exciting one.

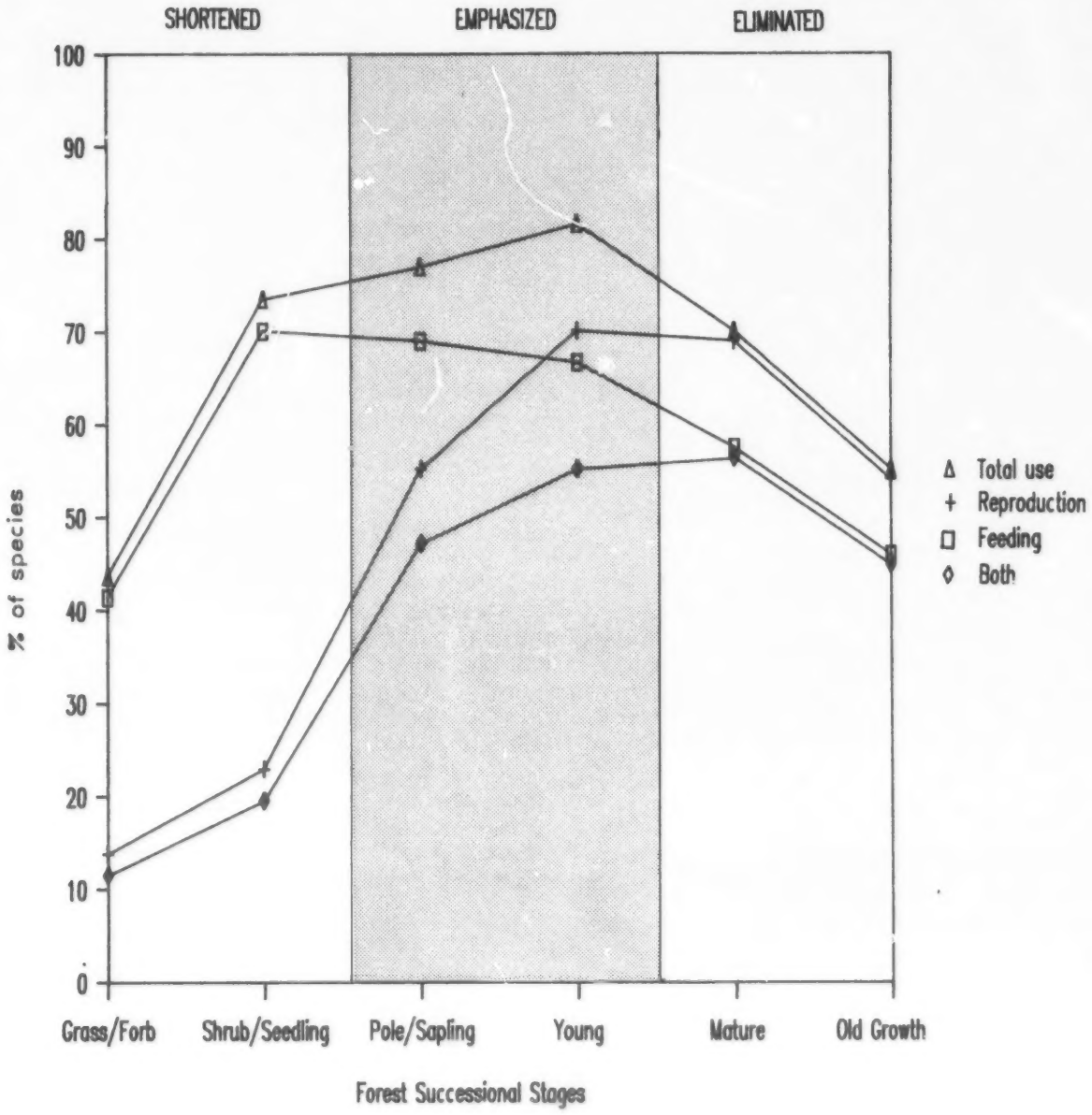

FIGURE 5. Orientation of all breeding bird species in selected lifeforms to forest successional stages and effects of intensive forest management on these stages.

TABLE 8. Old growth nesting species[1]

First order species[2]	Lifeform	Lifeform description
Hermit Thrush	3	ground nesting species
Northern Goshawk	6	conifer tree nesting species
Western Flycatcher	6	conifer tree nesting species
Olive-sided Flycatcher	6	conifer tree nesting species
Townsend's Warbler	6	conifer tree nesting species
Pine Grosbeak	6	conifer tree nesting species
Red Crossbill	6	conifer tree nesting species
Evening Grosbeak	7	deciduous or conifer tree nesting species
Pileated Woodpecker	8	primary cavity nesting species
Northern Flicker	8	primary cavity nesting species
Vaux's Swift	9	secondary cavity nesting species
Brown Creeper	9	secondary cavity nesting species
Second order species[3]		
Osprey	1	large limb nesting species
Black-headed Grosbeak	5	deciduous tree nesting species
Cooper's Hawk	7	deciduous or conifer tree nesting species
Western Tanager	7	deciduous or conifer tree nesting species
Red-breasted Sapsucker	8	primary cavity nesting species
Hairy Woodpecker	8	primary cavity nesting species
Downy Woodpecker	8	primary cavity nesting species
Three-toed Woodpecker	8	primary cavity nesting species
Common Barn Owl	9	secondary cavity nesting species
Western Screech Owl	9	secondary cavity nesting species
Northern Pygmy Owl	9	secondary cavity nesting species
Northern Saw-whet Owl	9	secondary cavity nesting species
Chestnut-back Chickadee	9	secondary cavity nesting species
Red-breasted Nuthatch	9	secondary cavity nesting species

[1] Data compiled from Appendix 5.
[2] Reproduces only in mature and old growth stages.
[3] Reproduces only in young, mature and old growth stages.

11 RESEARCH AND MANAGEMENT RECOMMENDATIONS

This analysis revealed the need for both research information and management action. Based on information reviewed, and the author's assessment of priorities for improving integrated management of timber and birds, recommendations for both are presented below. Recommendations are presented in three categories -- short, medium, and long term -- in order to provide guidance in developing an integrated series of research-management activities.

11.1 Short Term Recommendations

Given the current level of timber-bird management, short term recommendations focus on A) information needs associated with a direct threat of forest practices on a habitat requirement; B) information needed on the basic biology of a species in order to determine if a threat exists (concern is often generated about a species from a more general threat to the lifeform); and C) special habitat information needs.

11.1.1 Research

Research needs are listed in order of priority from highest to lowest, within each category. The species (Spp), habitat relationship of concern (HR), and a specific research question (Q) is presented to provide clear guidance for research investment.

A) Information needs associated with a threat of forest practices on a habitat requirement:

Spp: Pileated Woodpecker
HR: old growth nesting species; largest cavity nesting species; requires wildlife trees > 50 cm; trees of suitable size for cavity nesting is the ultimate factor limiting breeding habitat suitability
Q: What is the minimum number of wildlife trees required per Pileated Woodpecker breeding pair?
HR: area sensitive species
Q: What is the minimum nesting territory size per breeding pair?

Spp: Downy Woodpecker
HR: old growth nesting species; trees in advanced stages of decay needed as the substate for excavation
Q: What stage of tree deterioration is required by the Downy Woodpecker for excavation?

Spp: Hairy Woodpecker
HR: old growth nesting species; trees in advanced stages of decay needed as the substrate for excavation
Q: What stage of tree deterioration is required by the Hairy Woodpecker for excavation?

Spp: Brown Creeper
HR: old growth nesting species; snags or old trees with loose bark needed for nesting
Q: What age do trees develop bark characteristics suitable for Brown Creeper nesting activity?

B) Information needed to determine if a threat exists:

Spp: Marbled Murrelet
HR: nest site requirements unknown; hypothesized to nest primarily in old growth conifers
Q: What are the nesting habitat requirements of the Marbled Murrelet?

Spp: Vaux's Swift
HR: old growth nesting species; restricted breeding distribution, in Canada unique to B.C.
Q: What is the breeding distribution of Vaux's Swift on Vancouver Island?

Spp: Pine Grosbeak
HR: old growth nesting species; breeding distribution on Vancouver Island unverified
Q: Does the Pine Grosbeak nest on Vancouver Island?

Spp: Evening Grosbeak
HR: old growth nesting species; breeding distribution on Vancouver Island unverified
Q: Does the Evening Grosbeak nest on Vancouver Island?

C) Special habitat information needs

Wildlife Trees

1. Forest practices

Can wildlife trees be perputrated without creating unacceptable safety hazards?

2. Species requirements

What is the minimum number of wildlife trees needed to support a self-sustaining population?

Species, listed in rank order:

- Pileated Woodpecker
- Downy Woodpecker
- Northern Flicker
- Hairy Woodpecker
- Red-breasted Sapsucker
- Three-toed Woodpecker

This wildlife tree-species population relationship should be calculated for each biogeoclimatic zone -- coastal western hemlock (CWH), coastal Douglas-fir (CDF), mountain hemlock (MH) -- and for different population levels. A snag level of 40-percent of that required for a maximum bird species population is considered the minimum that will support a self-sustaining population (Thomas 1979, p. 72).

3. Wildlife tree dynamics

What is the wildlife tree recruitment rate?

What is the wildlife tree decay rate?

If possible, these rates should be calculated using existing forest inventory data.

What is the relationship between pathogen dynamics, rate of decay, and the development of wildlife tree characteristics for commercial tree species?

11.1.2 Management

The following are priority lists of management action needs. The activities of A) inventory and B) other management activites are used to structure the recommendations.

A) Inventory

1. Conduct an inventory on the following species; listed by priority (highest to lowest):

   . Pileated Woodpecker
   . Northern Goshawk
   . Bald Eagle
   . Downy Woodpecker
   . Hairy Woodpecker
   . Osprey

For each of these species, inventory should be conducted on both commercial and non-commercial lands. These inventory data will provide information on the extent to which non-commercial lands provide habitat to meet the species wildlife management objectives and distribution goals.

2. Implement an at-sea Marbled Murrelet census program

By monitoring the breeding population in their feeding habitat, changes in population size can be identified, and this information can be used to evaluate the hypothesis that clearcutting is eliminating Marbled Murrelet nesting habitat.

B) Other management activites

1. Develop species management objectives for:
    - . Pileated Woodpecker
    - . Northern Goshawk
    - . Bald Eagle
    - . Downy Woodpecker
    - . Hairy Woodpecker
    - . Osprey

    Species management objectives are a prerequisite to a population monitoring program. The objectives should be specific, time-bound, and measurable.

2. Revise the Bald Eagle and Osprey operational procedure guidelines outlined by Morrison and Janz (1983) to incorporate recent research findings from the U.S.A.

3. Implement Bald Eagle and Osprey operation procedures (#2, above, is a prerequisite).

4. Conduct breeding distribution surveys for:
    - . Vaux's Swift
    - . Pine Grosbeak
    - . Evening Grosbeak

11.2 Medium Term Recommendations

These recommendations follow from the short term recommendations and reflect the research and management needs associated with a more sophisticated intensive timber-bird management system. The same format as short term is used.

11.2.1 Research

The following are priority lists of research needs. They are described by A) categories of birds with similar key habitat requirements; species of concern are listed in rank order within categories, and B) special habitats of concern.

A. Categories of birds with similar key habitat requirements, i.e. species groups:

Old growth nesting species

- Pileated Woodpecker
- Bald Eagle
- Northern Goshawk
- Downy Woodpecker
- Hairy Woodpecker
- Brown Creeper

Cavity nesting species

- Pileated Woodpecker
- Downy Woodpecker
- Vaux's Swift
- Hairy Woodpecker

Large limb nesting species

- Bald Eagle
- Northern Goshawk
- Osprey

Obligate deciduous tree nesting species

species in this group will need to be assessed as stand tending practices become more sophisticated and intensive

Upper canopy nesting species

species in this group will need to be assessed as stand tending practices become more sophisticated and intensive.

For each of these species, Habitat Suitability Index (HSI) models (Schamberger et al. 1982) should be constructed. In building these models, specific species-habitat relationships that are weak or unknown will emerge and provide a focus for further research.

B. Special habitats of concern

Riparian

Riparian habitat management has been suggested as a possible mechanism for maintaining old growth habitat (Cline et al. 1980, Morrison and Meslow 1984). Questions to address include:

To what extent do riparian habitats meet the nesting habitat requirements of the following ranked species:

- Pileated Woodpecker
- Downy Woodpecker
- Northern Goshawk
- Vaux's Swift
- Red-breasted Sapsucker
- Black-headed Grosbeak
- Hairy Woodpecker
- Brown Creeper
- Bald Eagle
- Osprey

Does the quality of the riparian habitat change with:

1) width of the riparian zone;
2) successional stage of adjacent upland habitat; and
3) type of water source?

11.2.2 Management

The following are priority lists of management action needs. The same format as short term is used.

A. Inventory

Focus: species group(s); mid-successional commercial managed and unmanaged stands

Species groups (ranked):

- riparian habitat species
- old growth nesting species
- cavity nesting species
- large limb nesting species

. obligate deciduous tree nesting species

. upper canopy nesting species

These inventories would achieve the dual goals of numbers and habitat information as well as providing the information necessary to assess status regarding species management objectives.

B. Other management activities

Snag management models

Assess snag (wildlife tree) management models in order to select, refine, and test the model that best fits the current level of timber-bird management.

By using existing data to assess these models, any inadequency in the data base will be identified and will provide the focus for future research.

Blue grouse

Clarify whether the increase in Blue Grouse numbers after clearcutting is due to an increase in habitat quality or changes in the genetic composition of the population.

This information will aid in clarifying the role of forest management on Blue Grouse populations.

Management Guidelines

Test: Bald Eagle/Osprey operational procedure guidelines (refer to Section 11.1.2 (B)2 above).

Northern Goshawk management guidelines.

11.3 Long Term Recommendations

These recommendations are needs that will likely develop from the short and medium term research and management activities. They have already become concerns in other areas (e.g. some U.S.A. National forests). These recommendations serve as an indication that research and management should work towards longer term questions of broad scope.

11.3.1 Creating habitat in managed conifer stands

Species of concern (ranked):

- Pileated Woodpecker
- Northern Goshawk
- Downy Woodpecker
- Bald Eagle
- Vaux's Swift

For each of these species, consider the following questions:

How can nesting habitat be created in managed conifer stands?

What silvicultural prescription(s) produce nesting habitat most efficiently?

Are extended rotations a feasible management strategy?

Can nest site requirements be produced without extending the commercial forest rotation?

Is "clumping" (i.e. maintaining clumps of wildlife trees and live replacements) a viable timber-bird management strategy?

For Pileated Woodpecker, consider the following:

Can silvicultural prescriptions produce nesting habitat for self-sustaining populations at minimum and above minimum levels?

To what extent does Pileated Woodpecker breeding habitat fulfill the needs of other cavity nesting species?

Develop a working stand assessment and prescription tool.

Use the following flowchart (Figure 6) and associated habitat suitability (HSI) model as the framework for developing this tool.

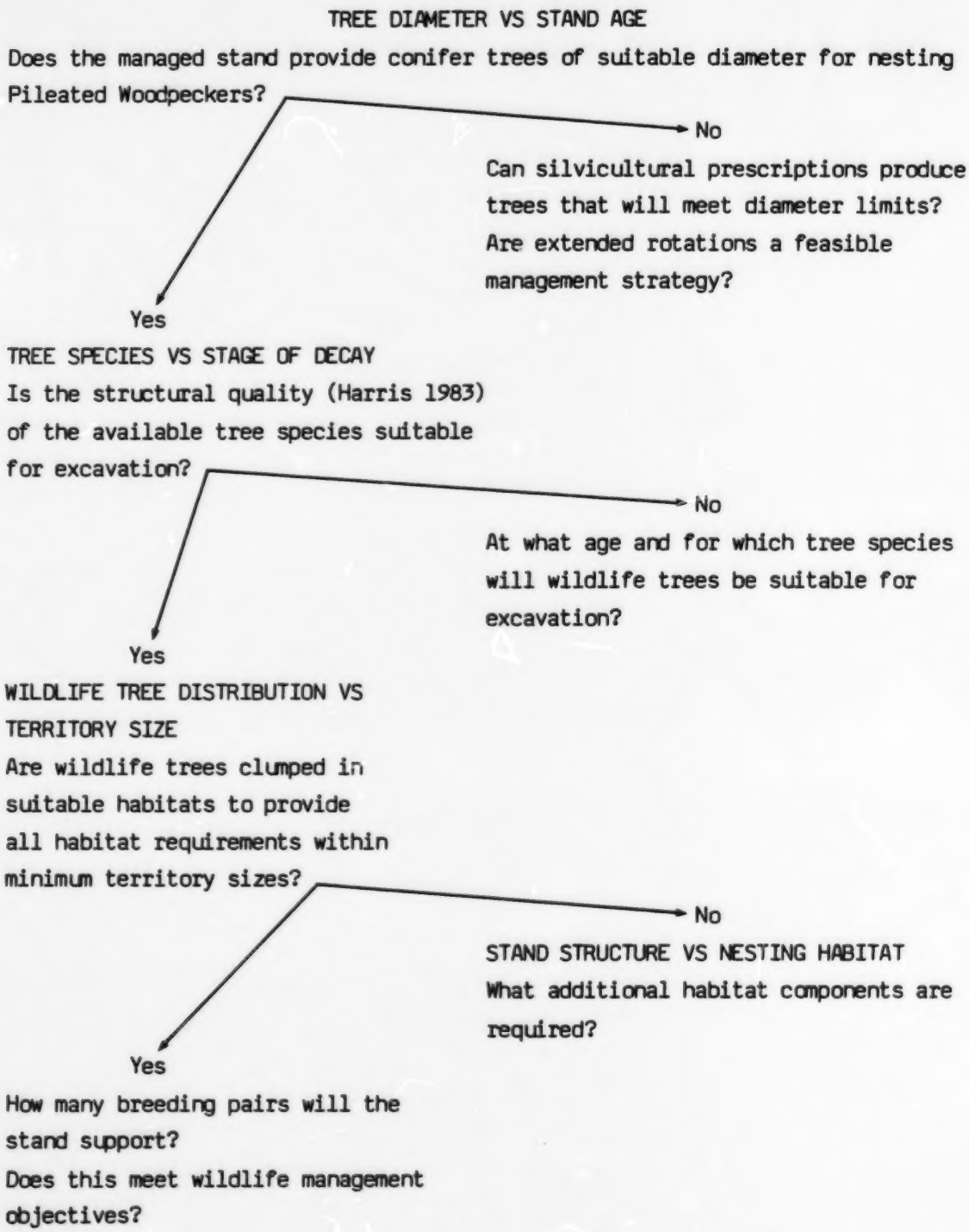
TREE DIAMETER VS STAND AGE
Does the managed stand provide conifer trees of suitable diameter for nesting Pileated Woodpeckers?
No
Can silvicultural prescriptions produce trees that will meet diameter limits? Are extended rotations a feasible management strategy?
Yes
TREE SPECIES VS STAGE OF DECAY
Is the structural quality (Harris 1983) of the available tree species suitable for excavation?
No
At what age and for which tree species will wildlife trees be suitable for excavation?
Yes
WILDLIFE TREE DISTRIBUTION VS TERRITORY SIZE
Are wildlife trees clumped in suitable habitats to provide all habitat requirements within minimum territory sizes?
No
STAND STRUCTURE VS NESTING HABITAT
What additional habitat components are required?
Yes
How many breeding pairs will the stand support?
Does this meet wildlife management objectives?

FIGURE 6. Pileated Woodpecker habitat assessment and prescription flowchart.

Establish a demonstration forest as a working example of the use of this management model.

11.3.2 Forest fragmentation

What is the relationship between bird species habitat use and the surrounding habitat mosaic?

What is the minimum patch size required for "area sensitive" forest birds?

What is the impact of forest fragmentation on alpha and beta species diversity?

What intensive forest management regimes can provide a habitat mosaic that will maintain bird species diversity and meet wildlife management goals?

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APPENDIX 1. Breeding bird species of Vancouver Island[a]

Indigenous Species

Common Name[b]	Scientific Name
Common Loon	Gavia immer
Red-throated Loon	Gavia stellata
Red-necked Grebe	Podiceps grisegena
Pied-billed Grebe	Podilymbus podiceps
Fork-tailed Storm Petrel	Oceanodroma furcata
Leach's Storm Petrel	Oceanodroma leucorhoa
Double-crested Cormorant	Phalacrocorax auritus
Brandt's Cormorant	Phalacrocorax penicillatus
Pelagic Cormorant	Phalacrocorax pelagicus
Great Blue Heron	Ardea herodias
Canada Goose	Branta canadensis
Mallard	Anas platyrhynchos
Green-winged Teal	Anas crecca
Blue-winged Teal	Anas discors
Cinnamon Teal	Anas cyanoptera
Wood Duck	Aix sponsa
Harlequin Duck	Histrionicus histrionicus
Hooded Merganser	Lophodytes cucullatus
Common Merganser	Mergus merganser
Turkey Vulture	Cathartes aura
Northern Goshawk	Accipiter gentilis
Cooper's Hawk	Accipiter cooperii
Red-tailed Hawk	Buteo jamaicensis
Bald Eagle	Haliaeetus leucocephalus
Osprey	Pandion haliaetus
Peregrine Falcon	Falco peregrinus

APPENDIX 1. Breeding bird species of Vancouver Island cont'd.

Common Name	Scientific Name
Merlin	Falco columbarius
American Kestrel	Falco sparverius
Blue Grouse	Dendragapus obscurus
Ruffed Grouse	Bonasa umbellus
White-tailed Ptarmigan	Lagopus leucurus
Sandhill Crane	Grus canadensis
Virginia Rail	Rallus limicola
Sora	Porzana carolina
American Coot	Fulica americana
Black Oystercatcher	Haematopus bachmani
Killdeer	Charadius vociferus
Common Snipe	Gallinago gallinago
Spotted Sandpiper	Actitis macularia
Glaucous-winged Gull	Larus glaucescens
Mew Gull	Larus canus
Common Murre	Uria aalge
Pigeon Guillemot	Cepphus columba
Marbled Murrelet	Brachyramphus marmoratus
Cassin's Auklet	Ptychoramphus aleuticus
Rhinoceros Auklet	Cerorhinca monocerata
Tufted Puffin	Fratercula cirrhata
Band-tailed Pigeon	Columba fasciata
Mourning Dove	Zenaida macroura
Common Barn-Owl	Tyto alba
Western Screech-Owl	Otus kennicottii
Great Horned Owl	Bubo virginainus
Northern Pygmy-Owl	Glacidium gnoma

APPENDIX 1. Breeding bird species of Vancouver Island cont'd.

Common Name	Scientific Name
Short-eared Owl	*Asio flammeus*
Northern Saw-whet Owl	*Aegolius acadicus*
Common Nighthawk	*Chordeiles minor*
Black Swift	*Cypseloides niger*
Vaux's Swift	*Chaetura vauxi*
Rufous Hummingbird	*Selasphorus rufus*
Belted Kingfisher	*Ceryle alcyon*
Northern Flicker	*Colaptes auratus*
Pileated Woodpecker	*Dryocopus pileatus*
Red-breasted Sapsucker	*Sphyrapicus varius*
Hairy Woodpecker	*Picoides villosus*
Downy Woodpecker	*Picoides pubescens*
Three-toed Woodpecker	*Picoides tridactylus*
Eastern Kingbird	*Tyrannus tyrannus*
Willow Flycatcher	*Empidonax traillii*
Hammond's Flycatcher	*Empidonax hammondii*
Western Flycatcher	*Empidonax difficilis*
Western Wood Pewee	*Contopus sordidulus*
Olive-sided Flycatcher	*Contopus borealis*
Horned Lark	*Eremophila alpestris*
Violet-green Swallow	*Tachycineta thalassina*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Barn Swallow	*Hirundo rustica*
Cliff Swallow	*Hirundo pyrrhonota*
Purple Martin	*Progne subis*
Gray Jay	*Perisoreus canadensis*

APPENDIX 1. Breeding bird species of Vancouver Island cont'd.

Common Name	Scientific Name
Steller's Jay	*Cyanocitta stelleri*
Common Raven	*Corvus corax*
Northwestern Crow	*Corvus caurinus*
Chestnut-backed Chickadee	*Parus rufescens*
Bushtit	*Psaltriparus minimus*
Red-breasted Nuthatch	*Sitta canadensis*
Brown Creeper	*Certhia americana*
American Dipper	*Cinclus mexicanus*
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Bewick's Wren	*Thryomanes bewickii*
Marsh Wren	*Cistothorus palustrus*
American Robin	*Turdus migratorus*
Varied Thrush	*Ixoreus naevius*
Hermit Thrush	*Catharus guttatus*
Swainson's Thrush	*Catharus ustulatus*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
Water Pipit	*Anthus spinoletta*
Cedar Waxwing	*Bombycilla cedrorum*
Hutton's Vireo	*Vireo huttoni*
Solitary Vireo	*Vireo solitarius*
Warbling Vireo	*Vireo gilvus*
Orange-crowned Warbler	*Vermivora celata*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Townsend's Warbler	*Dendroica townsendi*
MacGillivray's Warbler	*Oporonis tolmiei*

APPENDIX 1. Breeding bird species of Vancouver Island cont'd.

Common Name	Scientific Name
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Western Meadowlark	*Sturnella neglecta*
Red-winged Blackbird	*Agelaius phoeniceus*
Brewer's Blackbird	*Euphagus cyanocephala*
Brown-headed Cowbird	*Molothrus ater*
Western Tanager	*Piranga ludoviciana*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Evening Grosbeak	*Coccothraustes vespertinus*
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus cassinii*
Pine Grosbeak	*Pinicola enucleator*
Rosy Finch	*Leucosticte arctoa*
Pine Siskin	*Cardeulis pinus*
American Goldfinch	*Carduelis tristis*
Red Crossbill	*Loxia curvirostra*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Savannah Sparrow	*Passerculus sandwichensis*
Dark-eyed Junco	*Junco hyemalis*
Chipping Sparrow	*Spizella passerina*
White-crowned Sparrow	*Zonotrichia leucophrys*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*

APPENDIX 1. Breeding bird species of Vancouver Island concluded

Introduced Species

Common Name	Scientific Name
California Quail	Callipepla californica
Mountain Quail	Oreortyx pictus
Ring-necked Pheasant	Phasianus colchicus
Gray Partridge	Perdix perdix
Rock Dove	Columba livia
Eurasian Skylark	Alauda arvensis
European Starling	Sturnus vulgaris
House Sparrow	Passer domesticus

[a] Compiled in 1982.
[b] American Ornithologists' Union (1983).

Sources: Godfrey 1966, Campbell 1977, B.C. Wildlife Record Scheme, Campbell pers. comm.

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species

Lifeform 1: REPRODUCES near or on water.
FEEDS on ground; in shrubs, trees and water.

Common Loon*	Gavia immer
Red-throated Loon	Gavia stellata
Red-necked Grebe	Podiceps grisegena
Pied-billed Grebe	Podilymbus podiceps
Great Blue Heron	Ardea herodias
Canada Goose	Branta canadensis
Mallard	Anas platyrhynchos
Green-winged Teal	Anas crecca
Blue-winged Teal	Anas discors
Cinnamon Teal	Anas cyanoptera
Harlequin Duck	Histrionicus histrionicus
Common Merganser	Mergus merganser
Bald Eagle*	Haliaeetus leucocephalus
Osprey	Pandion haliaetus
Sandhill crane	Grus canadensis
Virginia Rail	Rallus limicola
Sora	Porzana carolina
American Coot	Fulica americana
Killdeer	Charadius vociferus
Common Snipe	Gallinago gallinago
Spotted Sandpiper*	Actitis macularia
Mew Gull	Larus canus
American Dipper	Cinclus mexicanus
Marsh Wren	Cistothorus palustris
Common Yellowthroat	Geothlypis trichas
Red-winged Blackbird	Agelaius phoeniceus

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 2: REPRODUCES in cliff, cave, rimrock and/or talus.
FEEDS on ground or in the air.

Turkey Vulture	Cathartes aura
Peregrine Falcon*	Falco peregrinus
White-tailed Ptarmigan	Lagopus leucurus
Black Swift	Cypseloides niger
Barn Swallow	Hirundo rustica
Cliff Swallow	Hirundo pyrrhonota
Common Raven	Corvus corax
Rosy Finch	Leucosticte arctoa
Rock Dove (introduced)	Columba livia

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 3: REPRODUCES on ground without specific water, cliff, rimrock or talus association.
FEEDS on ground; in shrubs, trees, water or the air.

Blue Grouse*	Dendragapus obscurus
Ruffed Grouse	Bonasa umbellus
Marbled Murrelet	Brachyramphus marmoratus
Short-eared Owl	Asio flammeus
Horned-Lark	Eremophila alpestris
Common Nighthawk*	Chordeiles minor
Hermit Thrush	Catharus guttatus
Water Pipit	Anthus spinoletta
Orange-crowned Warbler	Vermivora celata
Wilson's Warbler	Wilsonia pusilla
Western Meadowlark	Sturnella neglecta
Rufous-sided Towhee	Pipilo erythrophthalmus
Savannah Sparrow*	Passerculus sandwichensis
California Quail (introduced)	Callipepla californica
Mountain Quail (introduced)	Oreortyx pictus
Ring-necked Pheasant (introduced)	Phasianus colchicus
Gray Partridge (introduced)	Perdix perdix
Eurasian Skylark (introduced)	Alauda arvensis

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 4: REPRODUCES in shrubs.
FEEDS on ground; in shrubs, trees, or the air.

Rufous Hummingbird	Selasphorus rufus
Eastern Kingbird	Tyrannus tyrannus
Willow Flycatcher	Empidonax traillii
Bushtit	Psaltriparus minimus
Swainson's Thrush	Catharus ustulatus
Yellow Warbler*	Dendroica petechia
MacGillivray's Warbler	Oporonis tolmiei
Brewer's Blackbird	Euphagus cyanocephalus
Brown-headed Cowbird	Molothrus ater
American Goldfinch	Carduelis tristis
Dark-eyed Junco	Junco hyemalis
White-crowned Sparrow	Zonotrichia leucophrys
Fox Sparrow*	Passerella iliaca
Song Sparrow	Melospiza melodia

Lifeform 5: REPRODUCES primarily in deciduous trees.
FEEDS in shrubs, trees, or the air.

Red-tailed Hawk	Buteo jamaicensis
Mourning Dove	Zenaida macroura
Cedar Waxwing	Bombycilla cedrorum
Hutton's Vireo	Vireo huttoni
Solitary Vireo	Vireo solitarius
Warbling Vireo*	Vireo gilvus
Black-headed Grosbeak*	Pheucticus melanocephalus
House Finch	Carpodacus cassinii

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 6: REPRODUCES primarily in conifers.
FEEDS in shrubs, trees, or the air.

Northern Goshawk	Accipiter gentilis
Great Horned Owl	Bubo virginianus
Hammond's Flycatcher	Empidonax hammondii
Western Flycatcher*	Empidonax difficilis
Olive-sided Flycatcher	Contopus borealis
Steller's Jay*	Cyanocitta stelleri
Gray Jay	Perisoreus canadensis
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Yellow-rumped Warbler	Dendroica coronata
Townsend's Warbler*	Dendroica townsendi
Purple Finch	Carpodacus purpureus
Pine Grosbeak	Pinicola enucleator
Pine Siskin	Cardeulis pinus
Red Crossbill	Loxia curvirostra
Chipping Sparrow	Spizella passerina

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 7: REPRODUCES in conifers or deciduous trees.
FEEDS on the ground; in shrubs or trees.

Cooper's Hawk*	Accipiter cooperii
Merlin	Falco columbarius
Band-tailed Pigeon	Columba fasciata
Western Wood Pewee	Contopus sordidulus
Northwestern Crow*	Corvus caurinus
American Robin	Turdus migratorius
Varied Thrush	Ixoreus naevius
Western Tanager	Piranga ludoviciana
Evening Grosbeak	Coccothraustes vespertinus

Lifeform 8: REPRODUCES in excavated cavity in tree.
FEEDS on the ground or in trees.

Northern Flicker	Colaptes auratus
Pileated Woodpecker*	Dryocopus pileatus
Red-breasted Sapsucker	Sphyrapicus varius
Hairy Woodpecker	Picoides villosus
Downy Woodpecker*	Picoides pubescens
Three-toed Woodpecker	Picoides tridactylus

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species cont'd.

Lifeform 9: REPRODUCES in hole made by another or natural cavity.
FEEDS on the ground; in shrubs, trees, water, or the air.

Wood Duck	Aix sponsa
Hooded Merganser	Lophodytes cucullatus
American Kestrel	Falco sparverius
Common Barn-Owl	Tyto alba
Western Screech-Owl*	Otus kennicottii
Northern Pygmy-Owl	Glacidium gnoma
Northern Saw-whet Owl	Aegolius acadicus
Vaux's Swift	Chaetura vauxi
Violet-green Swallow	Tachycineta thalassina
Tree Swallow*	Tachycineta bicolor
Purple Martin	Progne subis
Chestnut-backed Chickadee*	Parus refescens
Red-breasted Nuthatch	Sitta canadensis
Brown Creeper	Certhia americana
House Wren	Troglodytes aedon
Winter Wren	Troglodytes troglodytes
Bewick's Wren	Thryomanes bewickii
European Starling (introduced)	Sturnus vulgaris
House Sparrow (introduced)	Passer domesticus

Lifeform 10: REPRODUCES in burrow underground.
FEEDS in the air or the water.

Belted Kingfisher*	Ceryle alcyon
Northern Rough-winged Swallow	Stelgidopteryx serripennis

APPENDIX 2. Lifeform descriptions
Asterik (*) denotes representative breeding bird species concluded

Lifeform 11: REPRODUCES on small coastal islands or coastal shores on the ground, cliffs or in burrows.
FEEDS in or on water.

Fork-tailed Storm-Petrel	Oceanodroma furcata
Leach's Storm-Petrel	Oceanodroma leucorhoa
Double-crested Cormorant	Phalacrocorax auritus
Brandt's Cormorant	Phalacrocorax penicillatus
Pelagic Cormorant*	Phalacrocorax pelagicus
Black Oystercatcher*	Haematopus bachmani
Glaucous-winged Gull	Larus glaucescens
Common Murre	Uria aalge
Pigeon Guillemot	Cepphus columba
Cassin's Auklet	Ptychoramphus aleuticus
Rhinoceros Auklet	Cerorhinca monocerata
Tufted Puffin	Fratercula cirrhata

APPENDIX 3. Life histories of representative breeding bird species

The information presented in the following tables was compiled using the following references:

Guiguet 1954
Guiguet 1955a
Guiguet 1955b
Guiguet 1957
Guiguet 1958
Guiguet 1960
Mussehl 1963
Guiguet 1964
Bendell and Elliot 1966
Godfrey 1966
Gabrielson and Jewett 1970
Guiguet 1972
Beebe, F.L. 1974
Jackman and Scott 1975
Van Camp and Henny 1975
Guiguet 1978
Ellison 1980
Stauffer and Best 1980
Verner and Boss 1980

APPENDIX 3. Life histories of representative breeding bird species cont'd.

Lifeform 1: REPRODUCES near or on water.
FEEDS on ground; in shrubs, trees, and water.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Common Loon *Gavia immer*	freshwater lakes; immatures frequent coastal inshore water	primarily freshwater fish; crustaceans, molluscs, few aquatic insects and reptiles	secured by direct underwater pursuit	reed construction nest, near water's edge, preferably on islands; usually only one pair per lake; eggs laid in May, incubation 29 days	common, but sensitive to human disturbance	low human disturbance
Bald Eagle *Haliaeetus leucocephalus*	usually in the vicinity of water; large rivers, lakes, seacoast and adjacent country side	primarily as scavenger, largely dead or dying fish; occasionally birds and mammals	on water surface and on ground by swooping from perch or air; along river estuaries	near top of thick branched tree; nests used for many years; incubation 35 days		absence of direct human disturbance; large coniferous trees for roosting, perching and nesting
Spotted Sandpiper *Actitis macularia*	sandy, rocky or muddy shore of freshwater or saltwater; favours coastal freshwater drainage areas across tidal mud and sand flats	insects, small crustaceans, molluscs, worms; other invertebrates; sometime seeds, berries	along fresh and saltwater shores - mudflats	a hollow on the ground not far from water; incubation 20 to 22 days	adaptable species	gravel or sandy salt or fresh water shores

Lifeform 2: REPRODUCES in cliff, cave, rimrock, and/or talus.
FEEDS on ground or in the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Peregrine Falcon *Falco peregrinus*	in breeding season, the vicinity of cliffs and adjacent country, coastal and inland; often about sea bird colonies; other seasons, prefers open country, shores and marshes frequented by birds	almost entirely made up of other birds; some rodents and insects	direct aerial pursuit and seizure or aerial dive; moving targets surrounded by unobstructed air space	little or no nest, eggs laid on cliff ledge, usually with a commanding view	suggested that numbers and distribution limited by method of predation (Beebe, F.L. 1974)	shoreline trees or cliffs for nesting; seabird colonies for food (coastal B.C.); low human disturbance

Lifeform 3: REPRODUCES on ground without specific water, cliff, rimrock or talus association.
FEEDS on ground; in shrubs, trees, water or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Blue Grouse *Dendragapus obscurus*	varies seasonally; in breeding season, lowland openings and edges; in winter, coniferous forests at higher altitudes	in summer, berries, seeds, young fir needles, buds, insects; in winter, coniferous buds and needles	gleaning, grazing, browsing on the ground and in conifers	in depression on ground at the foot of a tree, near a log or rock; eggs laid in April/June	maximum vertical migration 16 km; in breeding season, high density correlated with dominant conifer tree height (to 4 m and 20-50% ground cover)	medium to large forest openings of grass forb and shrub vegetation; open areas for courtship and mating; elevated ground or trees for hooting; minimum vegetation height of 20 cm for nesting
Common Nighthawk *Chordeiles minor*	open woodlands and cities	almost entirely insects, termites, beetles, winged ants, mosquitoes	insects taken on the wing	no nest; eggs laid on ground usually on sand, gravel, a flat rock, where protective colouration most effective; incubation approximately 19 days	its voracious appetite for insects make it extremely beneficial	open ground, sand or gravel, for nesting; open terrain for foraging
Savannah Sparrow *Passerculus sandwichensis*	open areas, especially moist grasslands and fields; marshes (salt and fresh), bog, grassy streamsides; areas with extensive tree cover are avoided	weed seeds and insects	on the ground	depression in ground usually sheltered by grass, shrubs, or small tree	primarily a ground bird but perches on fence posts, wires, bushes, and trees; its food habits make it a valuable bird on the farm	grasslands

Lifeform 4: REPRODUCES in shrubs.
FEEDS on ground; in water, shrubs, trees or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Yellow Warbler *Dendroica petechia*	deciduous thickets, especially willow and alder, on the moist edge of lakes, bogs, swamps; also garden shrubbery	mainly insects	gleans food from foliage of conifers and deciduous trees	in fork of shrub or tree, most often at a height between 0.9 and 2.4 m		dense shrub riparian habitat
Fox Sparrow *Passerella iliaca*	prefers sites with considerable shrub layer; woodland thickets and edges, burntlands, cutovers, riparian	mainly insects in summer; seeds in winter	on ground, scratches in litter under shrubs and in weed patches	in dense shrubs, occasionally on ground; nest height 0-1.8 m	especially common on east side of Van Is	dense shrub in moist areas with accumulation of litter

Lifeform 5: REPRODUCES primarily in deciduous trees.
FEEDS in shrubs, trees or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Warbling Vireo *Vireo gilvus*	mature deciduous trees, usually in upper stratum of leafy canopy; open deciduous and mixed woodlands, alder and willow thickets	mainly insects and spiders; also some fruits and seeds	gleans food from deciduous and coniferous foliage, also "hawks" for airborne insects	attached to terminal fork of branch; at a height between 1.2 and 12.8 m, usually above 2.4 m	suggested that cowbird nest parasitism caused population declines in parts of California; previously on Audubon "Blue List"	habitat patch size greater than 90 m^2 to support breeding population
Black-headed Grosbeak *Pheucticus melanocephalus*	more open deciduous and mixed wood forest, especially where there is an admixture of tall shrubbery adjacent to water; open second growth and bushy places	mainly seed eater, but many insects also eaten	picks fruit and buds from trees and shrubs or from ground; gleans insects from foliage, especially deciduous	tall shrubs or deciduous trees, often near water; usually 1.8 and 3.7 m above ground	optimal habitat riparian deciduous (California-Sierra Nevada)	

Lifeform 6: REPRODUCES primarily in conifers.
FEEDS in shrubs, trees or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Western Flycatcher *Empidonax difficilis*	shady more open areas below tree crown of mixed and conifer forests, especially moist (riparian) areas	flying insects	"hawking" from perches or taken from foliage	in variety of situations but often in crotch of tree near water, also on rock ledges		must have water and shade for nesting; perches for foraging
Steller's Jay *Cyanocitta stelleri*	coniferous or mixedwood forests, either extensive or broken; edges around slashes, rivers and shorelines	omnivorous; insects, cultivated berries and grains, birds eggs and young; also a scavenger	a variety of techniques, including gleaning and picking; takes food from foliage of conifers and deciduous trees and shrubs	usually in small or young firs (often Douglas-fir) between 2.4 and 12.2 m above ground; eggs laid April, early May		
Townsend's Warbler *Dendroica townsendi*	in breeding season, frequents cool coniferous forest; often sings high in treetops	mainly insects	gleans foliage of dense conifers, often forages in upper stratum	shallow cup in conifer		mature coniferous forests

Lifeform 7: REPRODUCES in conifers or deciduous trees.
FEEDS on the ground; in shrubs, trees or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Cooper's Hawk *Accipiter cooperii*	commonly found in transition zone of coniferous Douglas-fir and aspen, Douglas-fir and yellow pine, or deciduous river bottom lands	mainly small- to medium-sized birds; also small mammals	prey taken in air, on ground or off branches; element of surprise important to its hunting success; single attack common tactic	in conifers, near trunk; in deciduous trees, in upright crotch; average ht in even-aged stand 14.6 m in diverse-age conifer, 17.1 m		dense stand structure (young stage) nesting and in the vicinity of permanent water; forest edges for foraging; perch trees
Northwest Crow *Corvus caurinus*	open coastal woodlands usually not far from salt water; also freshwater shore	scavengers; insects, cultivated crops, eggs, young birds, aquatic shoreline life	on the ground or in trees	usually in trees, often deciduous thickets, between 6.1 and 15.2 m above ground, sometimes on ground in rock recesses	questionable whether this species is separate from the Common Crow	trees for roosting

Lifeform 8: REPRODUCES in excavated cavity in tree.
FEEDS on the ground or in trees.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Pileated Woodpecker *Picoides pileatus*	mature coniferous forests with intrusions of deciduous growth and snags	mainly insects, a high proportion of wood-boring species; also berries	drills into decaying wood of standing trees or fallen logs usually within 3 m of the ground	cavity excavated at a height between 4.6 and 21 m above ground in snag or, less often, living tree with an average diameter of 0.5 m; incubation 18 days	drills largest of woodpecker holes; may be sole provider of nest cavities for tree nesting ducks	hard nest snag in snag cluster in dense mature coniferous forest; low human disturbance
Downy Woodpecker *Picoides pubescens*	various situations where open deciduous, mixed deciduous or conifer forests, and tall shrubbery occur; prefers deciduous trees and tall shrubbery	mainly insects, adults and larvae; some fruits and seeds	probes and gleans insects from bark and branches of small trees, living or dead	cavity excavated at a height between 2.4 and 15.2 m above ground in dead tree; drilling and egg-laying begins in April/May	in trouble as a species on Van Is	snags or trees with soft heartwood

Lifeform 9: REPRODUCES in hole made by another or natural cavity.
FEEDS on the ground; in shrubs, trees, water or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Western Screech Owl *Otus kennicottii*	heavily wooded riparian (streams or running water) or wetland hardwoods; forest/ grassland edges	opportunistic feeder; seasonally variable - cricetid rodents in fall and winter, birds in spring and during nesting, insects, fish, amphibians during summer	primarily nocturnal, aerial search of prey by sight and sound	minimum nest height 4.6 m; minimum dbh 30.5 cm; eggs laid in April; incubation 26 days; will use nest boxes	defends territory 10 months of the year; breeding territory approx 364 m in diameter	protective daytime roosts (cavities or dense foliage); availability of water; absence of larger owls (predators); forest edges
Tree Swallow *Tachycineta bicolor*	prefers flooded or moist areas with snags within open forests or adjacent to open terrain	primarily flying insects; occasionally fruit and seeds	insects taken on the wing, mainly over water or moist ground; occasionally on the ground	minimum nest height 4.6 m; minimum dbh 25.4 cm; nest building begins April/May; incubation 13-16 days; will use nest boxes	obligate-hole nester; numbers governed by availability of suitable holes	nest cavity within open forest or adjacent to open terrain and water
Chestnut-backed Chickadee *Parus rufescens*	almost exclusively an inhabitant of mature coniferous forests during breeding season; prefers forest with dense upper story canopy	primarily insects; some conifer seeds and fruit	gleans food from foliage and twigs, preferably conifers; forages usually high in canopy	cavities usually within 3.1 m of ground (minimum 1.8 m); minimum dbh 10.2 cm; incubation 14 days	can excavate its own cavity in decaying wood	cavity or soft wood for excavation in stand with a dense upper story canopy

Lifeform 10: REPRODUCES in burrow underground.
FEEDS in water or the air.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Belted Kingfisher *Ceryle alcyon*	the vicinity of fish-inhabited water, preferably clear, either fresh or marine and with shoreline perches	mainly small fish; some insects and amphibians	dives from perch or hovering position above water	excavates long burrow, 0.9-2.1 m, in sandy or earthen bank usually by edge of water; opening usually within 0.6 m of top of bank and 1.5 m above water surface		earthen embankment for nesting; clear, fish-inhabited water for feeding; perches

APPENDIX 3. Life histories of representative breeding bird species concluded

Lifeform 11: REPRODUCES on small coastal islands or coastal shores on ground, cliffs or in burrows.
FEEDS in air or on water.

SPECIES	HABITAT	FOOD	FORAGING	NESTING	COMMENTS	HABITAT REQUIREMENTS
Fork-tailed Storm Petrel *Oceanodroma furcata*	open ocean provides winter habitat; in breeding season, comes to land, usually coastal islands	small marine crustaceans, squid, fish		excavates burrows not far below the surface; burrows 0.75 m in diameter and 0.6-1.2 m in length; eggs laid in May; incubation about 5 weeks	breeding distribution limited by occurrence of soft-soiled, predator-free islands	soft-soiled, predator-free islands
Pelagic Cormorant *Phalacrocorax pelagicus*	coastal salt water and adjacent cliffs, log pilings, sand bars and rocky islands	a wide variety of fish	two methods: schooling fish captured by direct underwater pursuit; sedentary fish seized under rock and other marine cover in which they hide	prefers narrow ledges of precipitous cliffs facing ocean or on islands; incubation 31 days		
Black Oystercatcher *Haematopus bachmani*	rocky, coastal saltwater shores and islands	mainly mussels; also other bivalves, small marine crustaceans, worms	probing and picking on rocky, intertidal shores	in depressions in rocks or hollows in gravel beaches; eggs laid in June	coast of B.C. mainland, Queen Charlotte Islands and Vancouver Island only areas in Canada where it occurs	

APPENDIX 4. Species vs habitat component. Table format follows from Thomas (1979). Information[a] presented was provided by Campbell (pers. comm.), with refinements from the literature.

SPECIES	HABITAT COMPONENTS: MARINE	RIVERS	STREAMS	LAKES	SLOUGHS	RESERVOIRS	PONDS	INTERMIT. PONDS	RUSH/CATTAIL - MARSH -	SEDGE - MARSH -	DECID. VEG.	STANDING WATER	RUNNING WATER	BEACHES	ESTUARIES	GRASS/SHRUB - EDGES -	SHRUB/FOREST - EDGES -	GRASS/FOREST - EDGES -	CONIFERS	SNAGS	LOGS	BURROWS	CLIFF/RIM ROCK	TALUS	CAVES
LIFEFORM 1																									
Common Loon*	F	F		X		X	X					X			F										
Red-throated Loon	F			X			X								F										
Red-necked Grebe	F	F		X	X										F										
Pied-billed Grebe	F			X	X	X	X		R	R		X			F				R						
Great Blue Heron	F	X	F	F	F	F	F	F	F	F	X	F		F	F		R								
Canada Goose		X		X	X	X	X		X	X	X	X			F	F									
Mallard		X	X	X	X	X	X	F	X	X	X	F			F	R					R				
Green-winged Teal		F		X	X	X	F	F	X	X		F			F	R									
Blue-winged Teal				X	X	X	X	F	X	X		F				R									
Cinnamon Teal				F	X	X	F	F	X	X		F			F	R			R	R					
Harlequin Duck	F	X	X	X								F	X		F										
Common Merganser	F	X	X	X	X								X						R	R					
Bald Eagle*	F	X		X	X	X	F		F	F	F	X	F	F	F				X	R					
Osprey	F	X		X	X	X	F					X			F	F			X	R					
Sandhill Crane		F		X	F		F		X	X	F					F									
Virginia Rail				X	X	X	X	F	X	X	F	X					X								
Sora			F	X	X	X	X	F	X	X	F	X					X								
American Coot		F		X	X	X	X	F	X	X	F	X			F										
Killdeer		X		X	F	X	X	F	F	X	F	X		X	F										
Common Snipe		F	F	F	X	X	X	F	X	X	F	F			F	R									
Spotted Sandpiper*		X	X	X	X	X	X	F		X	F	X		X	F	R				R	R				
Mew Gull	F	F		X	F	F	F	F			R	X	F	F	F										
American Dipper		X	X										X												
Marsh Wren				X	X	X	F		X	X	X	X					F								
Common Yellowthroat				X	X	F	X		X	X	F						X								
Red-winged Blackbird		F	F	X	X	X	X	F	X	X	X					X	X	F	F						
LIFEFORM 2																									
Turkey Vulture				F		F						F		F	F	F	F	F	F		R		R		R
Peregrine Falcon*	F	F		F	F	F	F		F	F		X		F	F		R		X	R			R	X	
White-tailed Ptarmigan																R				R			R		
Black Swift		F	F	F	F	F	F																		
Barn Swallow		F	F	F	F	F	F	F	F	F	F	F		F	F	F							X		
Cliff Swallow		X	F	X	F	X	F	F	F	F	F	F		F	F	F						X	X	R	
Common Raven			X	F	X	F	F	F	F							F	X	X	F				X	X	
Rosy Finch																									

[a] F - feeding only
R - reproduction only
X - feeding and reproduction
* - denotes representative breeding bird species in the lifeform

APPENDIX 4. Species vs habitat component cont'd.

SPECIES	MARINE	RIVERS	STREAMS	LAKES	SLOUGHS	RESERVOIRS	PONDS	INTERMIT. PONDS	RUSH/CATTAIL - MARSH -	SEDGE - MARSH -	DECID. VEG.	STANDING WATER	RUNNING WATER	BEACHES	ESTUARIES	GRASS/SHRUB - EDGES -	SHRUB/FOREST - EDGES -	GRASS/FOREST - EDGES -	CONIFERS	SNAGS	LOGS	BURROWS	CLIFF/RIMROCK	TALUS	CAVES
LIFEFORM 3																									
Blue Grouse*											F					X	X	X	R		X				
Ruffed Grouse		X	X	X		X					F					X	X		R		X				
Marbled Murrelet	X	F		X							X							R	R	R					
Short-eared Owl					F	X	F	F	F	X						X									
Common Nighthawk*		F	F	F	F	F	F																R	F	
Horned Lark																		X						X	
Hermit Thrush		X	X	F																					
Water Pipit						F																			
Orange-crowned Warbler		X	X	X							X					X	X			F					
Wilson's Warbler		F	F	X	F	X	X				F				F		X								
Western Meadowlark						F										X									
Rufous-sided Towhee		F	F	F		X					X					X	X				X				
Savannah Sparrow*		F	F	F	F	X	F	F		F						X									
LIFEFORM 4																									
Rufous Hummingbird		X	X	X		X					X			F		X	X								
Eastern Kingbird				X	X	X	X	F			X	X										F			
Willow Flycatcher		X	X	F	F	F					F					F	X								
Bushtit		F	F	F	X	X	X				X					X	X								
Swainson's Thrush		X	X	X	F													X							
Yellow Warbler*		X	X	X	X	X	X				X					F	F	F							
MacGillivray's Warbler		F	X	X	F	X	F				X					X	X	F							
Brewer's Blackbird		F	F	X	X	X	X	F	F	F	X					X	X	F							
Brown-headed Cowbird		X	X	X	X	X	X	X	X	X	X	F		F	F	X	X	X		X					
American Goldfinch				X	F	X					X					X	F	F				X			
Dark-eyed Junco		X	X	X		X	X	X									X	F				X			
White-crowned Sparrow		F	F	X	F	X					X					X	F	F				F			
Fox Sparrow*		X	X	X	X	X					F							X	X		F				
Song Sparrow		X	X	X	X	X					X					X	X				X				
LIFEFORM 5																									
Red-tailed Hawk		X		X	F	F	F					F			F	F	X	X	F	R			R		
Mourning Dove						F					X					X	R	X	F						
Cedar Waxwing		X	X	X	F	X	F				X						X	X	F	X					
Hutton's Vireo											X							X	F						
Solitary Vireo		F	X	X		X					F							X	F						
Warbling Vireo*		X	X	X	F	X	X				X					X	X	X	F						
Black-headed Grosbeak*		F	X	X	F	X					F					F	X	F							
House Finch						X					F														

APPENDIX 4. Species vs habitat component cont'd.

SPECIES	HABITAT COMPONENTS: MARINE	RIVERS	STREAMS	LAKES	SLOUGHS	RESERVOIRS	PONDS	INTERMIT. PONDS	RUSH/CATTAIL - MARSH	SEDGE	DECID. VEG. -	STANDING WATER	RUNNING WATER	BEACHES	ESTUARIES	GRASS/SHRUB -	SHRUB/FOREST EDGES	GRASS/FOREST -	CONIFERS	SNAGS	LOGS	BURROWS	CLIFF/RIN ROCK	TALUS	CAVES
LIFEFORM 6																									
Northern Goshawk		F	F	F							F	F					R	R	X						
Great Horned Owl		X	X	X	F	X	F	F			X	X			F	F	X	X	X	R			X		
Hammond's Flycatcher		X	X	F	F	F					F						X		X	F	F				
Western Flycatcher*		X	X	F	F	F					F						F		X	F	F				
Olive-sided Flycatcher		X	X	F	F	F					F						F	F	X	F	F				
Gray Jay		F	F	X							X					F	F		R						
Steller's Jay*		X	X	X	F	F					F						X	F	R		F				
Golden-crowned Kinglet		X	F	F		F					F						X	F	X						
Ruby-crowned Kinglet		X	X	X		F					X						F	F	X						
Yellow-rumped Warbler		X	X	X	F	X	F				X					X	F		X						
Townsend's Warbler*		X	X	F	F	X	F				F						X	X	X						
Purple Finch		X	X	X							F						X	X	X						
Pine Grosbeak		F	F	F													X	F	X						
Pine Siskin		X	X	X	F	X	F				F					F	X	X	X				F	F	
Red Crossbill		X	X	F		F	F				F						F	F	X						
Chipping Sparrow		X	X	X		X					X					X	X	X	R		X				
LIFEFORM 7																									
Cooper's Hawk*		X	X	X		F					F	F			F	F	F	F	X						
Merlin		X	X	X		F			F	F		X		F	F		F	F	X						
Band-tailed Pigeon						F					F				F	X	X	X	X						
Western Wood Pewee		X	X	X	F	F					F					X	X		R		F				
Northwestern Crow*		X	X	X	X	X	X	F	F	F	X			F	F	F	X	X	R						
American Robin		X	X	X	X	X	F	F	F	F	X			F		F	X	X	R						
Varied Thrush		F	F	X	F	F											X		R						
Western Tanager		F	F	X	F	X	F				X						X	X	R						
Evening Grosbeak		X	X	X							F						X	X	R						
LIFEFORM 8																									
Northern Flicker		X	X	X		X					X						X	F	R	X	F				
Pileated Woodpecker*		X	X	X		X											X		X	X	F				
Red-breasted Sapsucker		X	X	X	X	X					X						X		X	X	F				
Hairy Woodpecker		X	X	X		F					F						X	F	X	R	F				
Downy Woodpecker*		X	X	X	X	X			F		X						X	F	X	X	F				
Three-toed Woodpecker																	X	X	R	X					

APPENDIX 4. Species vs habitat component concluded

SPECIES	HABITAT COMPONENTS: MARINE	RIVERS	STREAMS	LAKES	SLOUGHS	RESERVOIRS	PONDS	INTERMIT. PONDS	RUSH/CATTAIL - MARSH	SEDGE - MARSH	DECID. VEG.	STANDING WATER	RUNNING WATER	BEACHES	ESTUARIES	GRASS/SHRUB - EDGES	SHRUB/FOREST - EDGES	GRASS/FOREST - EDGES	CONIFERS	SNAGS	LOGS	BURROWS	CLIFF/RIMROCK	TALUS	CAVES
LIFEFORM 9																									
Wood Duck		X	X	X	X	X	X	F				X					R		R	R					
Hooded Merganser	F	X	X	X	F	F	X						X		F				R	R					
American Kestrel		X		X	X	X					F	X				F	X	F	X	R					
Common Barn-Owl						F				F					F	F		F	X	R					
Western Screech-Owl*		F	X	X	F		F					X		F	F	F	X	X	X	R					
Northern Pygmy-Owl		X	X	X	X	X					X					F	X	X	X	X					
Northern Saw-whet Owl		X	X	X	F	X	F	F			X						X	X	X	R					
Vaux's Swift		F	F	F	F	F	F												R	R					
Violet-green Swallow		X	X	X	X	X	X	F	F	F	X			F	F		R	X	X	R			R	R	
Tree Swallow*		X	X	X	X	X	X	F	F	F	X			F	F		R	X	X	R			R		
Purple Martin				F	F	X	F	F			X						X		R	R					
Chestnut-backed Chickadee*	X	X	X	X	X	X	F	F		X							X	X	X	X	F				
Red-breasted Nuthatch		F	F			F					F						X	X	X	R					
Brown Creeper		F	F	F							F						X		X	X	F				
House Wren						X					X						X	X	R	R					
Winter Wren		X	X	X													X		R						
Bewick's Wren						X											F		P						
LIFEFORM 10																									
Belted Kingfisher*	F	X	X	X	F	X	F				F	F					R		F			R			
Northern Rough-winged Swallow		X	X	X	F	X	F	F	F	F	F			F	F							R			
LIFEFORM 11																									
Fork-tailed Storm-Petrel*	X																	R			R	R			
Leach's Storm-Petrel	X																	R			R	R			
Double-crested Cormorant	X			F								F											R		
Brandt's Cormorant	X																						R		
Pelagic Cormorant*	X	F										F											R		
Black Oystercatcher*	X													X	F										
Glaucous-winged Gull	X	X		F		F						F	F	F	F										
Common Murre	X																						R		
Pigeon Guillemot	X															R						R	R	R	
Cassin's Auklet	X																	R				R			
Rhinoceros Auklet	X														F			R			R	R			
Tufted Puffin	X																	R				R			

APPENDIX 5. Species vs successional stage. Table format follows Thomas (1979). Information[a] presented was provided by Campbell (pers. comm.), with refinements from the literature

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
LIFEFORM 1						
Common Loon*						
Red-throated Loon						
Red-necked Grebe						
Pied-billed Grebe						
Great Blue Heron			R	R	R	R
Canada Goose						
Mallard	R					
Green-winged Teal	R					
Blue-winged Teal						
Cinnamon Teal						
Harlequin Duck					R	R
Common Merganser			R	R	R	R
Bald Eagle*				R	R	R
Osprey				R	R	R
Sandhill Crane						
Virginia Rail						
Sora						
American Coot						
Killdeer	X					
Common Snipe						
Spotted Sandpiper*	X					
Mew Gull			R	R		
American Dipper						
Marsh Wren						
Common Yellowthroat	X	X				
Red-winged Blackbird		F	R	R		
LIFEFORM 2						
Turkey Vulture	F	F	F	X	X	X
Peregrine Falcon*	F			R	R	
White-tailed Ptarmigan	X					
Black Swift				F	F	F
Barn Swallow	F					
Cliff Swallow	F					
Common Raven	F	F	F	R	R	R
Rosy Finch						

[a] F - feeding only
R - reproduction only
X - feeding and reproduction
* - denotes representative breeding bird species in the lifeform

APPENDIX 5. Species vs successional stage cont'd.

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
LIFEFORM 3						
Blue Grouse*	X	X	X	F	F	F
Ruffed Grouse		X	X	X	X	X
Marbled Murrelet	R	R				
Short-eared Owl	X					
Common Nighthawk*	F					
Horned Lark	R					
Hermit Thrush			F	F	X	X
Water Pipit	F					
Orange-crowned Warbler		X	X	F		
Wilson's Warbler		F	R	R		
Western Meadowlark	X					
Rufous-sided Towhee	X	X	X			
Savannah Sparrow*	X	F				
LIFEFORM 4						
Rufous Hummingbird	F	X	R	R	R	R
Eastern Kingbird		X	X	X	X	X
Willow Flycatcher		F	X	X		
Bushtit		F	X	X	X	X
Swainson's Thrush		F	X	X	X	
Yellow Warbler*		X	X	X		
MacGillivray's Warbler	F	X	X	X		
Brewer's Blackbird	F	R	R	R		
Brown-headed Cowbird	X	X	X	X	X	X
American Goldfinch	F	X	X	X		
Dark-eyed Junco	X	X	X	X		
White-crowned Sparrow	X	X	X	X		
Fox Sparrow*	X	X	X	X		
Song Sparrow	X	X	X			
LIFEFORM 5						
Red-tailed Hawk	F	F	X	X	X	X
Mourning Dove	F	X	X			
Cedar Waxwing		F	X	X	X	
Hutton's Vireo		F	X	X	X	
Solitary Vireo			X	X	X	
Warbling Vireo*		F	X	X	X	
Black-headed Grosbeak*		F		X	X	X
House Finch	F	X	X	X	X	

APPENDIX 5. Species vs successional stage cont'd.

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
LIFEFORM 6						
Northern Goshawk	F	F	F		X	X
Great Horned Owl	F	F	F	X	X	X
Hammond's Flycatcher		F	X	X	X	
Western Flycatcher*		F	F		X	X
Olive-sided Flycatcher		F	F		X	X
Gray Jay		F	F	X	X	X
Steller's Jay*		F	X	X	X	X
Golden-crowned Kinglet		F	X	X	X	X
Ruby-crowned Kinglet		F	X	X	X	X
Yellow-rumped Warbler*			F	X	X	X
Townsend's Warbler			F	F	X	X
Purple Finch		F	X	X	X	X
Pine Grosbeak			F	F	X	X
Pine Siskin	F	F	F	X	X	X
Red Crossbill				F	X	X
Chipping Sparrow	F	X	X	X	X	X
LIFEFORM 7						
Cooper's Hawk*		F	X	X	X	
Merlin	F	F	X	X		
Band-tailed Pigeon		F	X	R		
Western Wood Pewee		F	X	X	X	X
Northwestern Crow*	F	F	X	X		
American Robin	F	X	X	X	X	
Varied Thrush		F	X	X	X	X
Western Tanager		F	F	X	X	X
Evening Grosbeak			F	F	X	X
LIFEFORM 8						
Northern Flicker	F	F	F		X	X
Pileated Woodpecker*				F	X	X
Red-breasted Sapsucker		F	F	X	X	X
Hairy Woodpecker		F	F	X	X	X
Downy Woodpecker*		F	F	X	X	X
Three-toed Woodpecker		F	X	X	X	

APPENDIX 5. Species vs successional stage concluded

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
LIFEFORM 9						
Wood Duck					R	R
Hooded Merganser					R	R
American Kestrel	F			R	R	
Common Barn-Owl				R	R	R
Western Screech-Owl*	F	F	F	X	X	X
Northern Pygmy-Owl	F	F	F	X	X	X
Northern Saw-whet Owl	F	F		X	X	X
Vaux's Swift				F	X	X
Violet-green Swallow	F	F	R	R	R	
Tree Swallow*	F	F	R	R	R	
Purple Martin	F	F	X	X		
Chestnut-backed Chickadee*	F	F	F	X	X	X
Red-breasted Nuthatch			F	X	X	X
Brown Creeper				F	X	X
House Wren	F	F	R	R		
Winter Wren		F	X	X	X	X
Bewick's Wren		F	X	X		
LIFEFORM 10						
Belted Kingfisher*			X	X	F	F
Northern Rough-winged Swallow	X	F				
LIFEFORM 11						
Fork-tailed Storm-Petrel*	R	R	R	R	R	R
Leach's Storm-Petrel	R	R	R	R	R	R
Double-crested Cormorant						
Brandt's Cormorant						
Pelagic Cormorant*						
Black Oystercatcher*						
Glaucous-winged Gull						
Common Murre						
Pigeon Guillemot	R					
Cassin's Auklet	R			R	R	R
Rhinoceros Auklet	R			R	R	R
Tufted Puffin	R					

APPENDIX 6. Percent species use of forest successional stages by lifeform[a]

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
Lifeform 1						
% F	12	8	0	0	0	0
% R	8	4	12	23	19	19
Total[b]	19	8	15	23	19	19
% F[c]	0	0	0	0	0	0
% R[c]	0	0	50	100	100	100
Total[c]	0	0	50	100	100	100
Lifeform 2						
% F	75	25	25	25	25	25
% R	13	0	0	38	38	25
Total	75	25	25	50	50	38
Lifeform 3						
% F	54	46	39	31	23	23
% R	54	39	39	15	15	15
Total	69	54	46	38	23	23
Lifeform 4						
% F	64	93	86	79	29	21
% R	36	79	100	93	36	29
Total	64	100	100	93	36	29
Lifeform 5						
% F	38	88	88	88	88	25
% R	0	25	88	88	88	25
Total	38	88	88	88	88	25
Lifeform 6						
% F	25	75	94	81	100	94
% R	0	6	38	63	100	94
Total	25	75	94	81	100	94

APPENDIX 6. Percent species use of forest successional stages by lifeform[a] Cont'd.

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
Lifeform 7						
% F	33	89	100	89	67	44
% R	0	11	78	89	67	44
Total	33	89	100	100	67	44
Lifeform 8						
% F	17	83	83	83	100	83
% R	0	0	17	68	100	83
Total[b]	17	83	83	83	100	83
Lifeform 9						
% F	53	59	41	59	47	47
% R	0	0	35	77	82	65
Total[b]	53	59	59	88	76	65
Lifeform 10						
% F	50	50	50	50	50	50
% R	50	0	50	50	0	0
Total[b]	50	50	50	50	50	50
Lifeform 11						
% F	0	0	0	0	0	0
% R	50	17	17	33	33	33
Total[b]	50	17	17	33	33	33
All species						
% F	35	50	48	47	41	33
% R	19	18	41	54	52	41
% F and R[d]	11	15	31	37	38	31
Total[b]	42	54	58	63	54	44

APPENDIX 6. Percent species use of forest successional stages by lifeform[a] Cont'd.

	Grass Forb	Shrub Seedling	Pole Sapling	Young	Mature	Old Growth
Selected Lifeform Species[e]						
% F	41	70	69	67	57	46
% R	14	23	55	70	69	54
% F and R[d]	11	20	47	55	56	45
Total[b]	44	74	77	82	70	55

[a] Information in Appendix 5 was used to calculate percentages.
[b] Percentage of lifeform species using the successional stage; total of F, R, and X.
[c] Percentage calculated includes only four species: Great Blue Heron, Common Merganser, Bald Eagle, and Osprey; this subgroup was used for the analysis on the effects of forest practices.
[d] Percentage of all species that feed and reproduce in the same successional stage; total of Xs.
[e] Includes lifeforms 3 through 9 and four species from lifeform 1 (see 'c' above).

APPENDIX 7. Effects of intensive forest management on selected breeding bird lifeforms

Selection criteria:

Lifeform or the group of species within a lifeform that require forests or occur in stages of forest succession during forest development to climax.

Selected lifeforms include:

Lifeform 1 - Tree nesting species only
Lifeform 3 - Ground nesting species
Lifeform 4 - Shrub nesting species
Lifeform 5 - Deciduous tree nesting species
Lifeform 6 - Conifer tree nesting species
Lifeform 7 - Deciduous or conifer tree nesting species
Lifeform 8 - Primary cavity nesting species
Lifeform 9 - Secondary cavity nesting species

NOTE: Lifeforms 2, 10, and 11, and non tree nesting species in Lifeform 1 are not included.

The effects of the forest practices presented in the following table consider the lifeform as it acts as a functional niche. Details on lifeform and species responses documented in the literature and hypothesized in this analysis are discussed in the text (Sections 10.3 to 10.10 inclusive).

APPENDIX 7. Effects of intensive forest management on selected breeding bird lifeforms Cont'd.

CLEARCUTTING

A: Response to removal of all tree species
B: Response to conversion of habitat to early succession vegetation; response to increased habitat availability in grass/forb and shrub/seedling stages

SITE PREPARATION

A: NO SITE PREPARATION - logging slash remains; response to post-logging slash
B: BURNING - Response to elimination of logging debris

SITE ESTABLISHMENT

A: NATURAL REGENERATION - Response to natural revegetation of the site following clearcutting
B: PLANTING - Response to planting conifer seedlings; seedlings provide perch, cover, or food

STAND TENDING
DECIDUOUS/CONIFER COMPETITION

A: Mechanical - response to elimination of competing deciduous vegetation and increased ground debris
B: Herbicides - response to alteration of competing deciduous vegetation; dead, standing vegetation remains
C: Advances forest succession; response to vegetation changes from shrub stage to precommercial thinning (pole/sapling stage)

PRECOMMERCIAL THINNING (cut trees remain)

A: Response to opening the canopy, increased understory, reduced stand density, increased ground debris
B: Advances forest succession; response to vegetative changes from pole/sapling stage to commercial thinning (young stage)

COMMERCIAL THINNING (trees harvested)

A: Response to opening the canopy, increased understory, reduced stand density
B: Advances forest succession; response to vegetation changes in young stage to rotation

APPENDIX 7. Effects of intensive forest management on selected breeding bird lifeforms concluded

			CLEARCUTTING		NO SITE PREP		BURNING		NATURAL REGEN		PLANTING		DECID/CONIFER COMPETITION			PRECOMMERCIAL THINNING		COMMERCIAL THINNING	
			A	B	A	B	A	B	A	B	A	B	A	B	C	A	B	A	B
LIFEFORM	1	F	-	0	0	0	0	0	0	0	0	+	0	+	0	+			
		R	-	0	0	0	0	0	0	0	0	+	0	+	0	+			
LIFEFORM	3	F	+	+	0	0	+	+	-	-	+		+	+	+	+			
		R	+	+	0	0	+	0	-	-	+		+	+	+	+			
LIFEFORM	4	F	+	+	+	0	+	+	-	0	+		+	+	+	+			
		R	+	+	0	0	0	0	-	0	+		+	+	+	+			
LIFEFORM	5	F	+	+	+	0	+	0	-	-	+		+	+	+	+			
		R	-	0	0	0	0	0	-	-	+		+	+	+	+			
LIFEFORM	6	F	-	+	0	0	0	0	0	0	+		-	+	-	+			
		R	-	0	0	0	0	0	0	0	+		-	+	-	+			
LIFEFORM	7	F	-	+	0	0	0	0	0	0	+		-	+	0	+			
		R	-	0	0	0	0	0	0	0	+		-	+	-	+			
LIFEFORM	8	F	-	+	+	-	0	0	0	0	0		-	-	-	+			
		R	-	0	0	0	0	0	0	0	0		-	0	-	-			
LIFEFORM	9	F	-	+	+	-	0	0	0	0	0		-	-	-	+			
		R	-	0	0	0	0	0	0	0	0		-	0	-	-			

Key: F feeding
R reproduction
\+ positive effect on majority of species in lifeform
\- negative effect on majority of species in lifeform
0 no effect

APPENDIX 8. Personal communications

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